FOOD TECHNOLOGY

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PITTSBURGH IN '57

Last Call for ABSTRACTS

December 15, 1956

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December, 1956 Volume 10, Number 12

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New Savorlock cans for hygroscopic products combine long shelf life and positive reseal

Intended to spur impulse sales of instant coffee and other "hard-to-hold" products, Continental's newly announced Savorlock cans are believed to be the first of their category to be made on high-speed lines for maximum economy.

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Intensive store evaluations show no appreciable moisture pickup four months after stocking. After tamper-proof glassine inner seal is broken, the lock top gives a positive reseal in day-to-day home use.

Supermarket time studies reveal it takes a shopper an average of 4 seconds to choose an item from a grocery shelf. New Savorlock cans, in 2 and 6-oz. capacity, are specifically designed for today's impulse buying.

PERTINENT DATA ON THE NEW Savorlock CANS

The full opening and positive resealing features recommend Savorlock for almost any powdered or granulated product, food or non-food. Evaluations have been confined to instant coffee as being one of the most hygroscopic of food products now marketed. Other products for which tests can be arranged include:

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- Peanut butter
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IFT ACTIONS AND REACTIONS...

"TIME-TEMPERATURE TOLERANCE OF FROZEN FOODS"—DEFINITIVE REPORT ON THE BEHAVIOR AND CONTROL OF FROZEN FOODS

In a series of articles, beginning in the January issue of FOOD TECHNOLOGY, the comprehensive, authoritative investigations of the U. S. Department of Agriculture on frozen foods will be reported. For the past several years the Western Utilization Research Branch of the Department's Agricultural Research Service has been engaged in studying, phase by phase, the performance of frozen food throughout the cycle of production and distribution. Particular emphasis is on the phenomena of freezing and holding conditions. The product of this effort represents a major contribution to the science and technology of what is now a full-fledged branch of the great food industry; namely, commercial frozen foods.

Considered nationally, thousands of tons of food are moved from areas of production to freezer plants and on to the consumer, through devious channels of supply, by means of refrigerated trucks, cars, and in limited degree, by air freight. In the complex food economy of today, frozen food is then "metered"out to the consumer, in accordance with demand, days, weeks, or months after its original harvest. To maintain control of quality, nutritional value, and costs during this period of lag, food scientists and engineers have devoted endless hours to ascertaining (1) the factors involved in the physical and chemical changes in food processed by freezing and (2) the principles of equipment design, processing procedures, and storage control whereby top-quality frozen food products can be attained. Packers, warehousemen, transportation interests, and distributors—all urged that this investigation be undertaken. As mentioned, the first phases of this important study are now complete and the findings have been translated into a series of articles that describe the performance of "commercially packed frozen foods held under the whole range of conditions encountered in all phases of distribution." The project has had the dynamic interest and support of associations, private companies, Government agencies, and individuals concerned with frozen food, and its handling, transportation, and storage. Acknowledgment in full detail is made in the articles making up the series and cannot be reported in this space. It is sufficient to say, for present purposes, that the frozen food industry has been and is solidly lined up behind this theory-finding and fact-finding endeavor.

Without diminishing the importance of the many competent publications concerned with particular frozen items under selected low-temperature conditions and the contributions to the theoretical aspects of freezing, it is possible to say that this series of articles on the time-temperature tolerance of frozen foods will present for the first time an organized, full account of the pertinent scientific and technological knowledge necessary for the effective and efficient control of frozen foods from point of production to the consumer's table. The series will represent not a bench mark but as definitive a treatment of this vital time-temperature problem as can be made available. In a day when the exciting but still experimental modes of preservation tend to divert attention from the advances being made in the established food preservation processes, these frozen food studies, which FOOD TECHNOLOGY is privileged to present beginning in January, will have a healthful influence.

COMMITTEE ON EDUCATION APPOINTED

President Garnatz has appointed an IFT Committee on Education. There are two Sub-Committees—one Sub-Committee on Professional Status and one on Accreditation. Dr. Walter Maclinn, Chairman of the Food Technology Department at Rutgers University, was appointed to head the committee.

The Sub-Committee on Professional Status is composed of:

Dr. C. K. Wiesman, Chairman
Col. R. A. Isker
Dr. R. T. Milner

Responsibilities of this Sub-Committee are:

1. Suggest procedures that can be used by industry and educational institutions to stimulate the young potential scientist to seek food technology (by any name) as his training and career.

2. Plan methods by which industry and educational institutions can recruit potential scientists to food technology curriculums.

3. Design procedures by which the food industry can make the general public aware of the gigantic scientific strides being made in the industry.

4. Explore ways and recommend means for improving the professional status of the food technologist in industry.

The Sub-Committee on Accreditation is composed of:

Mr. L. J. Kenyon, Chairman
Dr. C. O. Ball
Mr. F. K. Lawler

Responsibilities of this Sub-Committee are:

1. Establish the desirable and undesirable facets of accreditation through consultation with the accrediting agency of other professional societies.

2. Delineate the types of training that should be offered to potential food technologists, i.e., for research, for production, etc.

3. Frame a basic curriculum of the fundamental sciences that would be common to all types of training.

(Continued on page 6)

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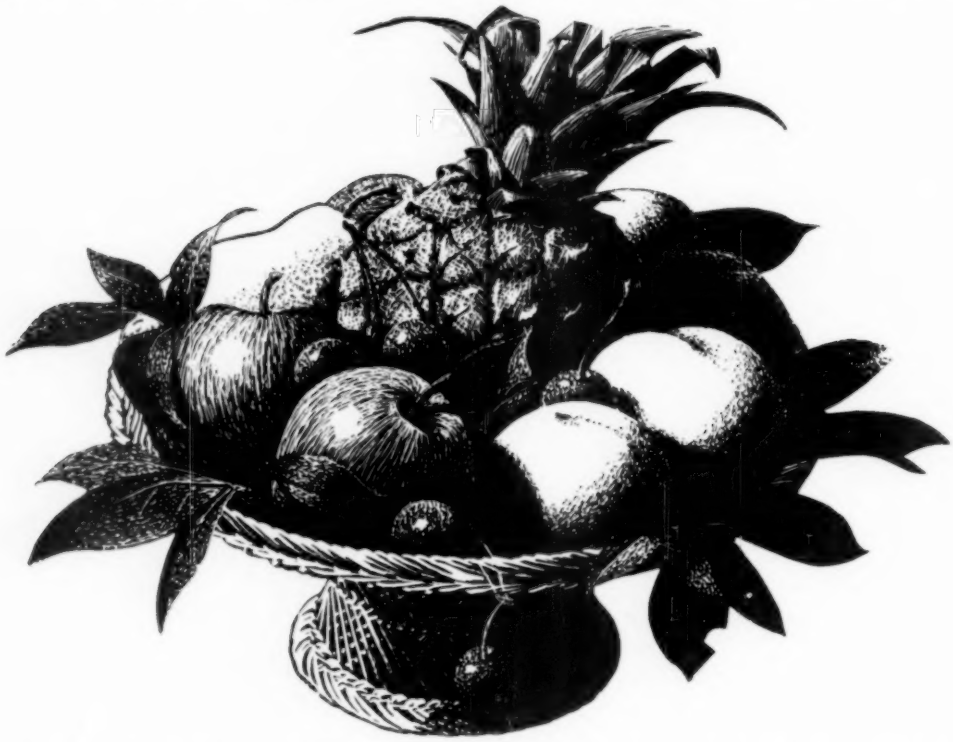

The foods shown here, like many others, are subject to oxidation during processing. Ascorbic acid will make them better by protecting them from the loss of natural color and flavor which oxidation causes. Small quantities of added ascorbic acid will greatly retard this action. When you use ascorbic acid in the easy, inexpensive Roche method to keep Nature's color and flavor in the foods you process, retail customers like them better and buy more.

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Editorial Office: 11606 South Bell Avenue, Chicago 43, Illinois

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Editor Emeritus

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Office of the Editor

11606 South Bell Avenue, Chicago 43

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Business Manager

CHARLES S. LAWRENCE

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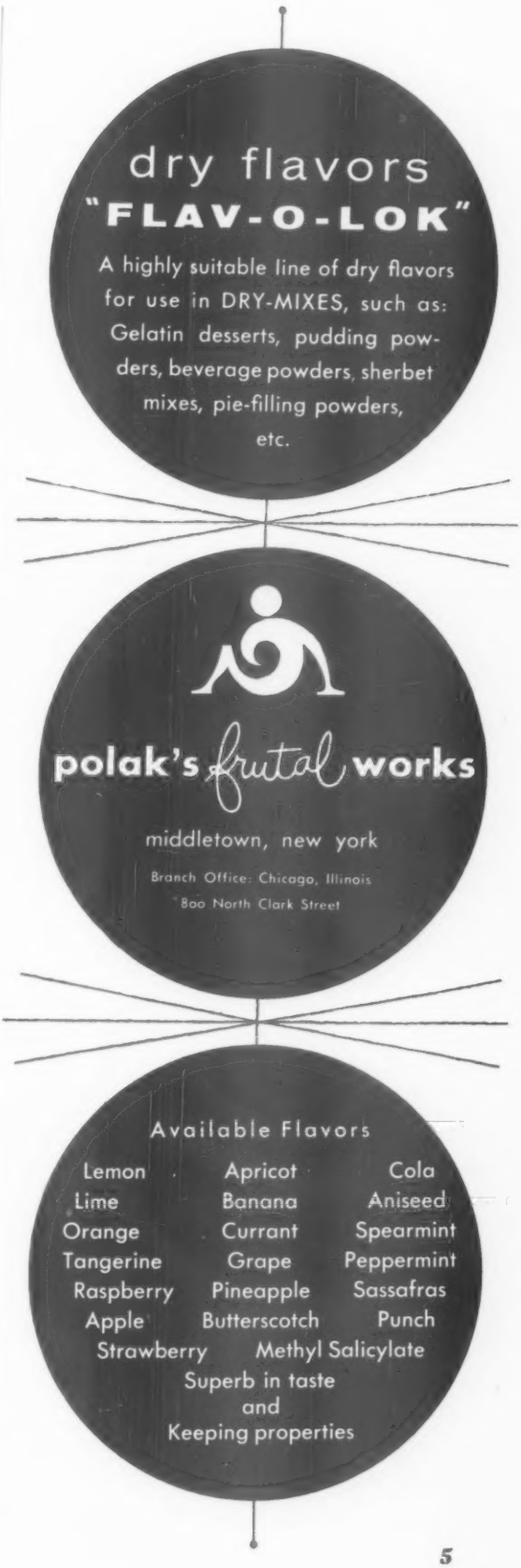

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(Continued from page 2)

4. Suggest programs of study to supplement the basic science curriculum to accommodate the needs of special sections of the food industry.

THE SAMUEL CATE PRESCOTT FELLOWSHIP FOR THE ACADEMIC YEAR 1957-58

The Refrigeration Research Foundation, Inc. announces that the Fellowship Award honoring Dr. Samuel Cate Prescott, Emeritus Dean of Science, M.I.T., and the Foundation's Chairman of the Board is open for applications. As previously, the Fellowship carries with it a stipend of $2500 to be used for the academic expenses of "a graduate student (in the U.S.A. or Canada) in the field of food refrigeration or food technology, with special reference to the application of refrigeration to foods." In order to qualify the applicant must be a senior undergraduate with better than an average scholastic record or a graduate with a B.Sc. or equivalent, preferably with honors, from an institution of good standing.

Applicants should (1) prepare their applications in letter form giving name, nationality, sex, age, marital status, physician's statement of health, college scholarship record, noteworthy academic accomplishments, and job experience and (2) request a letter of recommendation (to be sent separately) from each of three faculty members who have supervised the scholastic or research work of the applicant *and* a statement by the Head of the Department where the applicant will do his work, endorsing the applicant and accepting for the school the responsibility connected with the acceptance of the Award.

Address applications to

MR. H. C. DIEHL
Secretary and Director
The Refrigeration Research Foundation
12 North Meade Avenue
Colorado Springs, Colorado

BANGKOK CONGRESS ANNOUNCED

The 9th Pacific Science Congress will be held in Bangkok, Thailand, November 18-December 9, B.E. 2500 (1957) under the auspices of His Majesty's Government of Thailand, and Science Society of Thailand. Nutritionists, dietitians, food technologists, and other persons interested in or doing work on food, diet, nutrition, etc., are cordially invited to participate in the Nutrition Branch of the 9th Pacific Science Congress. The technical meetings, discussions, and symposia will take place during the first two weeks. The third week will be devoted to scientific and technical excursions. Details and other relevant documents may be obtained from the Secretariat, Department of Science, Ministry of Industry, Bangkok, Thailand.

LAST CALL FOR NOMINATIONS FOR BABCOCK-HART AWARD

In accordance with the Council's recent revision of the Rules and Regulations governing the Babcock-Hart Award, nominations may now be made by members of

(Continued on page 8)

The Quicks and the **vitamins**

This is the Jane Armbruster that was. She used to check vitamin A potency of fish liver oils on our old spectrograph like this back in the forties.

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(Continued from page 6)

the Institute as well as by members of the Jury. Nominations should be in the form of a one-page, single-spaced, typewritten letter giving a biographical sketch and qualifications of the individual for the Award. Such letters should be sent to Dr. L. E. Clifcorn, Chairman, Babcock-Hart Award Jury, American Can Company, Research Division, Barrington, Illinois. They must be received by January 15, 1957.

ADDITIONAL DONOR TO CAREERS BROCHURE FUND

An additional donation to the fund for the distribution of the Careers Brochure has been received from the American Meat Institute. Previous donors were listed in the October issue of FOOD TECHNOLOGY. The brochure has been distributed to high schools, guidance councilors and teachers, and to individual students. Over 85,000 copies have been sent out and the requests are still coming in.

MASTERS AND DOCTORS IN FOOD TECHNOLOLGY AND RELATED SUBJECTS

An additional entry has been supplied, as follows:

CORNELL UNIVERSITY, ITHACA, N. Y.

Name	*Degree*	*Title of Thesis*
Tolle, Wayne E.	Ph.D.	Progress in the Development of an Electrochemical Method for the Measurement of Volatile Flavors in Vegetables.

FEATURING THIS MONTH . . .

Food Technology Program and Objectives at the University of California*

E. M. Mrak
University of California

THE PROGRAM OF THE DEPARTMENT OF FOOD TECHNOLOGY is primarily in the areas of teaching and research. The research program is wide and extensive since the department is responsible for investigations on the processing of all foods produced in California except wines, dairy, and poultry products, although active collaborative projects with the departments of Enology, Dairy Industry, and Poultry are under way. It is apparent that it would be neither pertinent nor interesting to attempt to discuss researches pertaining to all the commodities with which we have been and are concerned.

Raw materials are truly important insofar as the quality and yield of processed product are concerned, and especially insofar as the profits realized in any processing activity. A failure to realize the importance of raw materials by a processor may very well result in the failure of his organization.

On many occasions during the past few years, I have been literally overwhelmed by a realization that food technologists frequently do not understand the importance of raw materials in processing. This was driven home to me very emphatically a few months ago, when one of the journals in the area of food science indicated that one of our papers should have been published in a horticultural journal rather than a food technology journal because a large portion of the paper was devoted to horticultural practices. Actually, this paper was presented to a food science journal with the view of orienting food technologists to the importance of the time of harvest of a particular commodity to the quality of the finished product. If this view persists, then food technologists may very well be responsible for diminished profits, or even a lack of profit.

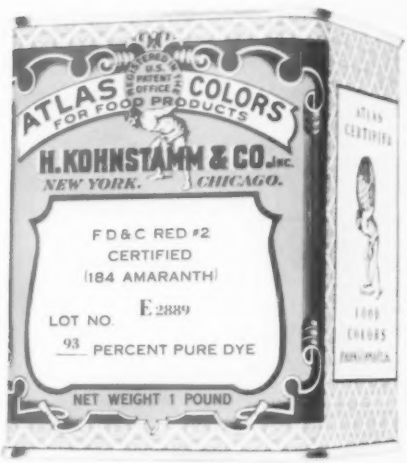
In our teaching, we are driving this point home more and more. We are insisting that the students learn about raw materials and the relation of cultural, harvesting, and transportation practices to the condition of the raw materials and the ultimate quality, yield, and salability of the processed product. It is pointed out, with emphasis, to students that this general principle applies, whether it be fruits, vegetables, fish, meat, honey, or other commodities.

It seems to me that the thinking in the meat industry is ahead of that in the fruit and vegetable canning industry. On many occasions I've talked to people in the meat processing industry and have been impressed with their interest in the feeding and handling of meat animals before slaughter. In the fruit and vegetable canning industry, on the other hand, I've heard little discussion along these lines. There is a wide range of maturity in handling certain fruit, but I have seen little curiosity concerning the relation of maturity to the quality of the canned product. Only recently have I seen a curiosity with respect to the relation of fertilization practices, pruning, hormone treatments, transportation practices, etc., to the quality of canned pears. There has been considerable discussion concerning the relation of irrigation to the yield of canned peaches. It appears that when the term "case yield" comes into the picture there is more interest. However, when the term quality is

(Continued on page 10)

* Presented at second annual conference of California Processors Fieldmen.

FOOD NEEDS COLOR



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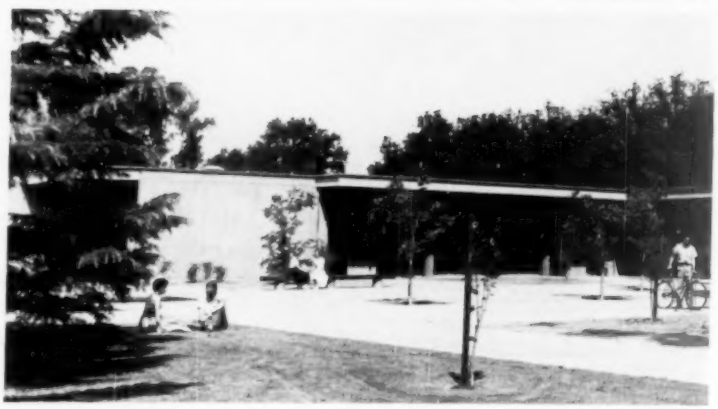

An aerial view of the Campus at Davis with the city of Davis in the background (above) and a close-up of the campus (right) giving a glimpse of student life (quiet phase) on a sunny day in late spring.

(Continued from page 8)

mentioned, unfortunately there has been less interest. It is my feeling that this attitude is now changing. I sincerely hope this is true, and that it will change more as time goes on. Much of our experimental program at Davis is directed toward leading the way in this connection, and pointing out some of the relationships indicated above.

The food technology program

With this brief prologue we can now get back to the food technology program at the University of California. First of all, it would be well to discuss briefly the philosophy of the program as now under way at Davis. In order to do this, a few words should be said about the history of the Department of Food Technology. The Department started at Berkeley, first as one concerned only with wines, but changing during the prohibition period to one concerned with processed foods. At Berkeley, laboratory space was limited, pilot plant operations were not available, and the staff was located at a considerable distance from the production departments at Davis. Because of this, research efforts were restricted, to a large extent, to what could be done in the laboratory, except in cases when work was done in manufacturing plants in cooperation with food processors.

In 1952, however, a large part of the Department moved to Davis, where it has been possible to utilize the team work approach. Thus, we have worked with the production departments—Vegetable Crops, Pomology, Poultry, Animal Husbandry, Apiculture, and Viticulture. It has also been possible to work with the Departments of Agricultural Engineering, Entomology, and Plant Pathology and Dairy Industry. This has enabled us to pursue a whole new area of investigation. In order to pursue the program, it was necessary to have a pilot plant. The California canning industry helped greatly in equipping our plant so that foods could be processed in very small or large quantities by typical commercial practices. This has been a very important asset. It is possible to produce 10 or 1,000 cans of a

(Continued on page 12)

THE Sealva STORY OF "Sealed-In" Flavors

Some years ago, van Ameringen-Haebler, Inc. developed and introduced SEALVA Flavors, the first truly hermetically "sealed-in" high quality dry flavors. This new technique in flavor-making was immediately recognized and enthusiastically accepted by the food industry.

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Where can SEALVA Flavors be used to advantage?

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(Continued from page 10)

commodity under commercial conditions. This cannot be done very easily in commercial plants during the operating season, because of the nuisance value experimental work imposes on the processors during their busy time.

The pilot plant . . . it is capable of production runs up to 1000 cans of a commodity under study.

Full-Spectrum Research

In order to conduct an effective research program, it is necessary to follow the full-spectrum plan. We can do this by working with the production departments, thus, we study the influences of various cultural practices on the canned product, trace the influences of technological and processing practices on the quality of the canned product, run taste-acceptance tests in our laboratory, and finally determine the influence of storage on the quality of the processed product. This is but one type of full-spectrum thinking of the Department of Food Technology.

We may look at the full-spectrum line of research from another point of view. The pilot plant operation permits the consideration of applied problems. These problems, however, cannot always be solved by such studies alone, and it is often necessary to use more specialized chemical, microbiological, physical and engineering procedures. It is not likely that any one person can pursue applied studies on the one hand and very complicated chemical studies on the other, such as those involving fat oxidations, enzyme reactions, color changes, etc. For this reason the interest and work of different staff members in the Department varies from the applied end of the spectrum, on the one hand, to the highly theoretical on the other. In many cases, however, there is an integration of effort—the team approach.

A Classical Example. A classical example of how the full spectrum of research works is a project concerned with the discoloration of canned green asparagus shortly after opening the can. Professor Marsh, with Mr. Dame, collaborated with the Department of Vegetable Crops to study the effect of cultural practices, location, and time of harvest on the development of this off-color. Furthermore, they studied the effect of various commercial processes used in the packing of canned asparagus. This was done in our pilot plant. Finally, chemical studies were pursued in collaboration with Dr. Chichester to determine what specific chemicals might be involved, and the chemical mechanism by which the discolorations occur.

By following such a procedure, it has been possible to show that cultural practices or time of harvest are not factors involved in the production of the off-color. It appears, however, that certain processing practices may have an influence. Finally, considerable information has been obtained concerning the mechanism of the reaction. While a large portion of this work has been done in collaboration with people on the Davis campus, a considerable amount of it has also been done in collaboration with the National Canners Association and others interested in the problem. Because of this general approach and collaborative effort, a great deal of progress has been made on this important problem in a year. It is hoped that such collaborative effort can be expanded to enable consideration of other problems of importance to the canning industry of California. As a matter of fact, a series of such collaborative projects has been started, and in several cases is already yielding valuable results.

Studying the chemical mechanism of discoloration in asparagus.

Here are further examples of full-spectrum research. Presently, it is not feasible to produce navel orange juice concentrate, because of the development of a bitter principle in the juice. Professor Marsh, in collaboration with the Department of Subtropical Horticulture, has shown that this is related to the type of root stock used on the orange. The root stocks, unfortunately, were developed without consideration of their relation to the quality of the processed product, for at the time these root stocks were developed, processing of citrus products was at a minimum. In this study, subjective evaluation picked up a defect in the processed product

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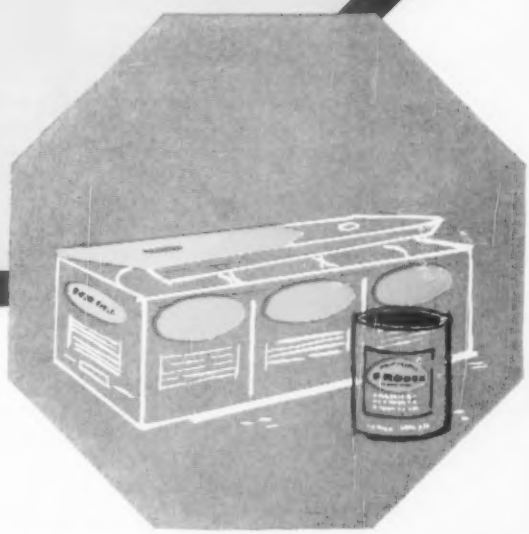

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(Continued from page 12)

that could be traced to the root stock, a finding not possible with chemical analysis alone. This is truly an example of getting "at the root of the problem."

For many years the beef producers of the West have been handicapped by the term "Kansas fed steer beef," as compared with "Western fed steer beef." Studies conducted by Dr. Hinreiner, and Miss Simone of the Department of Food Technology in collaboration with the Department of Animal Husbandry have indicated that there is no basis for prejudice against the Western-fed beef.

Although our research is solidly founded on regional problems, this is the type of research that often crosses borders to help others. In Brazil, effort is being devoted to studies with the relation of cultural practices to the quality of brewed coffee. Strangely enough, this program has been based to some extent on the raw materials program under way at Davis. It has taken a great deal of imagination to translate results from work on pears, peaches, and apricots to that which might be done on coffee. It has been my first hand observation that, although the work in Brazil has been under way but one year, it is already yielding results.

Other noteworthy projects

Let's continue with some of the specific activities under way in the department. One of our projects is concerned with the eating quality of canned pears. For many years, pears have been harvested at a pressure ranging from 14 to 20 pounds, stored near the cannery, until ripe, sorted and canned. Little attention was paid to the relation of the harvesting or ripening practices to quality or yield of the product. When Mr. Leonard joined the Department at Davis, he was well aware of this problem because of his experiences in industry. He collaborated with Dr. Claypool of Pomology, on studying the relation of the maturity and ripeness of the canned pear to the eating quality of the product. They showed that flavor of the canned pear could be greatly improved. However, we were unable to stimulate much interest in the work by the canning industry until it was realized that our procedures might also increase case yield. I believe you know the story from here on. There has been a tremendous interest in the harvesting and ripening procedures. Ripening rooms are now being installed in a number of canneries.

Other work under way on canned pears is concerned with the relation of nitrate fertilizer and other cultural practices to quality. This year, over 40 variables relating to culture and ripening are being considered.

All samples will be subject to acceptance testing by Miss Simone in our acceptance laboratory. Experience has shown that the acceptance values may change with storage, so in all cases, samples from the same lot are tested periodically over a period of a year. At the time the taste tests are made, Dr. Luh, of the Food Technology Department, makes certain chemical and physical measurements. These vary according to the commodity, but for pears may include drained weight, texture, sugar-acid ratio in the fruit, volatile reducing substances, vitamin C, etc. This procedure brings into consideration the factor of storage stability. More intense consideration of other chemical or physical factors could very well involve other members of the department. Such a full spectrum of consideration has enabled the use of a variety of specialized talents varying from the horticulturist and applied processor to chemical and acceptance laboratory testing to more theoretical laboratory consideration.

We have done work in collaboration with the Department of Entomology to determine the effect of a number of miticide sprays on the taste of canned pears. This work has terminated, but it was shown that certain sprays can adversely affect the taste of the canned product.

Elly H. Hinreiner (left), instructor in food technology and in charge of the food acceptance laboratory, is supervising Edith S. Bockian (right) as she makes up samples of pears for taste tests. Shirley L. Cleveland (center) is watching the process. The samples in the small beakers are then handed to the members of the taste panel through the steel doors in rear.

Studies on pitting and peeling procedures indicate that these may be important factors in determining the taste of the canned product. For many years we have accepted canning procedures without questioning their relation to flavor. Even now there is some reluctance to give serious consideration to flavor possibilities unless it can be demonstrated that case yield may be involved. It is our hope that the flavor of the canned cling peaches will show a definite improvement as a result of the changes in cultural, harvesting, handling, and processing techniques.

The production of strawberries in California today is considerable. As time goes on it will increase and perhaps become one of our very important processing fruits. In line with this we have had under way for a number of years a study of factors influencing the color of strawberry jam and preserves. The initial work in this direction was done in the laboratory by Dr. Mackinney to determine the mechanisms involved in color changes, the chemical nature of the pigments, and the chemical nature of the off-color. This has been very fruitful work and has resulted in a follow-up with certain pilot plant operations. It has been shown that metallic contamination, air, and heat greatly influence pigment breakdown during processing. In following up

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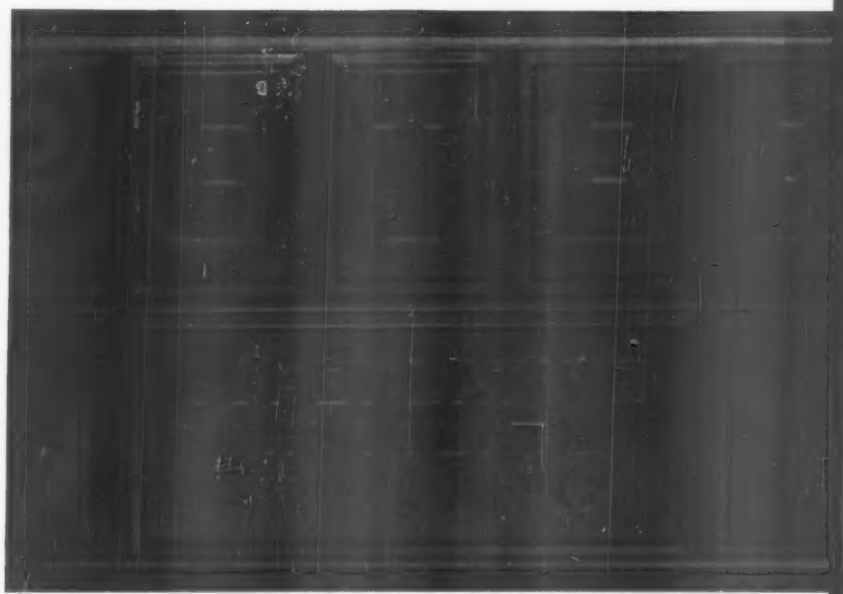

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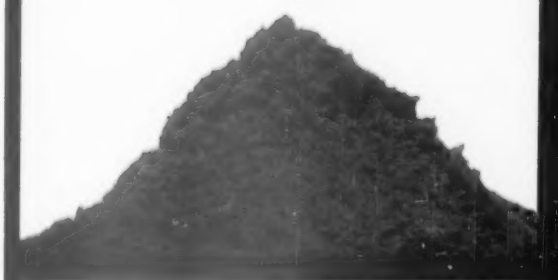

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(Continued from page 14)

on these experimental observations, Dr. Chichester designed a vacuum pan, which was installed in the pilot plant. The theories evolved by Mackinney and Chichester have been substantiated by pilot plant runs on strawberries.

As time goes on, other factors will be studied. Undoubtedly there is a good possibility that cultural practices, variety, area of production and handling of the raw material after harvest may have a tremendous effect on the color of the strawberry. Most certainly, some of these will prove to have an effect on the flavor of the processed berry.

A great amount of work has been done on olives by Professor Cruess, who retired a short while ago. Dr. Vaughn is carrying on in this area. Presently he has, in collaboration with Dr. Hartmann of the Department of Pomology, a project to determine the suitability of new varieties of olives for processing. They also have under way a study concerned with the influence of various agricultural chemicals on the eating quality of processed olives. They have shown conclusively that benzene hexachloride and lindane, when applied to the soil or tree under certain conditions, can cause the development of very serious off-tastes in the canned product. This off-taste may be so serious that the olives become inedible. The great need for food technologists to be ever alert and well informed on the cultural practices with respect to any commodity they may be processing is well documented in this one instance. The collapse of an industry could be involved.

It is also of interest that a blue discoloration has shown up in green ripe olives this year. It is possible that the nature of the color may be quite similar to that occurring in green asparagus. A study of this problem is under way, and the experience that had been obtained in organizing the program on asparagus is proving most helpful in pursuing this problem on olives.

We have a large program at Davis on tomatoes. It is our hope that it can be expanded to enable consideration of the influence of various cultural practices, variety, and handling procedures on the quality of the processed product insofar as color, taste, and storage stability are concerned.

It is our hope that the results of studies on tomatoes will not only give us data of importance with respect to variety, standards of maturity, fertilization and other cultural practices on the canning quality of the tomato, but perhaps also on yield of the processed product. This work is being done in cooperation with the Department of Vegetable Crops—another example of our "teamwork" approach.

The boysenberry crop is increasing to the point where the industry can well afford to consider processing more of the fruit. This spring we started some studies on boysenberry juice and syrups. During the next production season we may be able to follow through on other factors, as has been done with some of the fruits indicated above.

Freestone peaches are also being studied in a manner similar to that used on cling peaches. Other areas of research involve flavor in canned mushrooms, eating quality of dried prunes, studies on sweet potatoes, canned grapes, honey, etc.

Although some engineering corrections remain to be made in our freezing plant, we should soon be able to embark on a program concerned with frozen products along the lines outlined for canned foods.

Teaching—a vital function

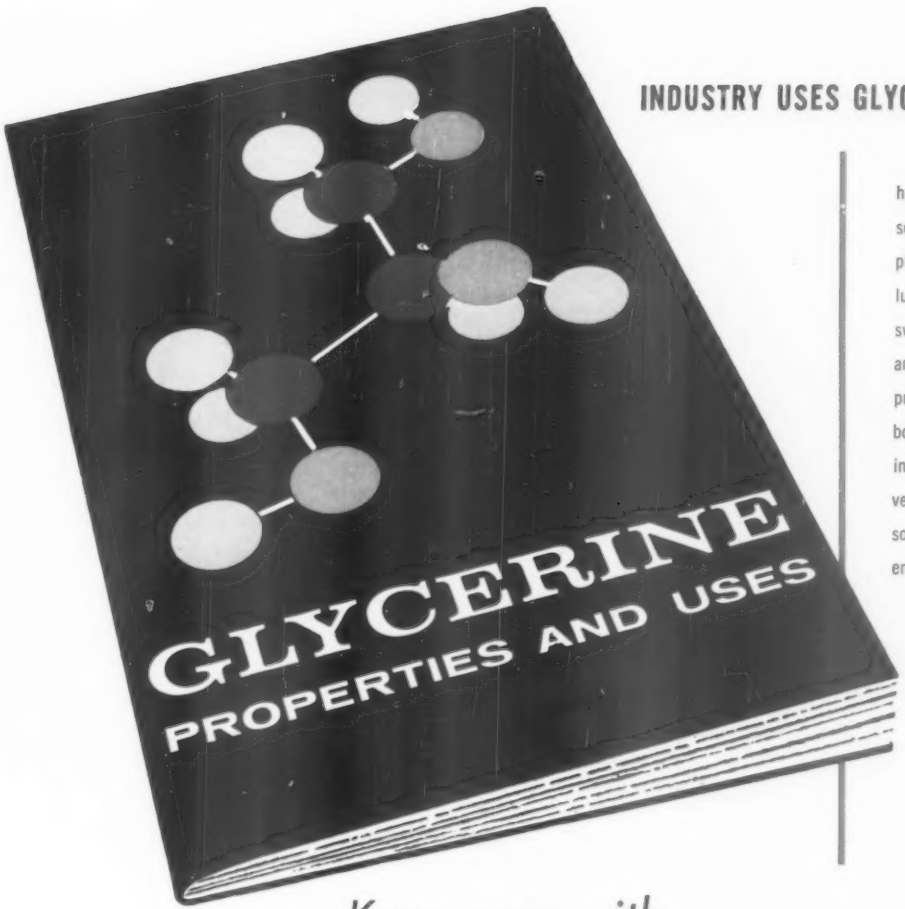
In conclusion, I wish to make reference to the most vital function of a modern university—teaching. We have both undergraduate and graduate teaching programs. Since the Department has been established on the Davis campus we have been reviewing our undergraduate teaching program. This may go on for some time because of the changing needs of graduates in the virtually new world of science and technology now unfolding. More and more of our students are going into food plant production work. Because of new trends and techniques in food preservation we have found it necessary to revise certain aspects of our teaching program. In a period of acute scientific manpower shortage, we recognize the need to keep pace with the times and to train students for the challenging years ahead.

Our graduate instruction leads to the M.S. and Ph.D. degrees. The M.S. degree, given in the field of food science, involves one to two years of additional study and presentation of a thesis resulting from laboratory study.

The Ph.D., on the other hand, is not given in the field of food technology, although our staff members supervise students working for this degree. The degree is given in a basic science, such as microbiology, agricultural chemistry, comparative biochemistry, botany, chemical engineering, etc. The student must fulfill the requirements for the basic field as well as those for a minor in food technology. This means, then, that not only does he have a good training in food technology but also a firm foundation in a basic science. It has been our feeling that although this places an added burden on the graduate student, it helps to develop his creativeness and he is better equipped to pursue research in the areas concerned with foods. Needless to say the food industry presents innumerable opportunities to the man or woman with a bent for research.

It generally takes a graduate student three to four years to obtain his Ph.D. degree. He must pass language examinations in French and German, pass a preliminary examination in basic and minor fields, and then present a thesis resulting from original research on some problem acceptable in the basic field and yet of interest to the member of the staff of the Department of Food Technology under whom he works. Achieving a Ph.D. requires work and hard concentration but to the person with the proper incentive and energy there is no more stimulating task or more satisfying reward.

We can summarize our objectives by stating that we strive to do a good job in teaching undergraduate and graduate students and in pursuing a full-spectrum research program—from cultural practices to processing, storage, and consumption; and from applied research to highly theoretical studies.



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IFT REGIONAL SECTIONS . . .

SPEECHES, SPECIAL EVENTS, NEWS NOTES

CHICAGO . . .

The October holiday at Madison, with the University of Wisconsin and the Wisconsin Alumni Research Foundation as hosts, was a memorable occasion both from the educative standpoint and the pleasure point of view. October 6, date of the visit, turned out to be a day full of interesting sights, beginning with the Campus itself, one of the most beautiful in the nation. What can be done with trees, hillocks and hummocks, a lake, winding lanes and driveways, and handsome, well-equipped buildings is illustrated at Madison. Naturally, it takes a little time plus vigorous, far-sighted planning to provide so inspiring a setting for learning, teaching, and research.

The tours were expertly conducted. Beginning with the Wisconsin Alumni Research Foundation and its extensive research and research services program in the biological, chemical, microbiological, entomological and other fields, the tour was picked up again at the spacious, well-equipped Dairy and Food Industries building, Babcock Hall, on the Campus proper. Here visiting Chicago section and IFT members from outlying areas were shown various projects in dairy and food research including the studies on whole dry milk—where excellent progress is being made, on cheese—a famous product of the State, on by-products of milk, and those on vegetables and fruit. Dr. H. T. Scott and Dr. L. J. Teply for WARF and Dr. K. G. Weckel for the University of Wisconsin part of the tour furnished, with many able assistants, the technical information necessary to understanding the various projects and the progress being made. Things are well in hand at Madison and the food industry and the taxpayers of Wisconsin are the beneficiaries of a highly competent food research and technology program.

A delicious luncheon was served at noon by the University of Wisconsin student Food Technology Club, and afterwards the crowd made its way to the University of Wisconsin-Southern California football game. The latter team won, but the hard-fought game and other features of the spectacle, for example, the performance of the band between halves, made the pleasant autumn day complete.

For so interesting and profitable a visit and for their fine hospitality thanks are due to Dr. Teply and his colleagues of the Wisconsin Alumni Research Foundation and to Dr. K. G. Weckel and associated faculty members of the Department of Dairy and Food Industries, University of Wisconsin.

At its meeting on November 12 at the Palmer House the Section had its usual pre-dinner get-together. After dinner, the group assembled to hear Dr. J. H. Toulouse, Chief Engineer, Quality and Specifications Department, Owens-Illinois Glass Co., Toledo, Ohio. Speaking on the subject "Finding the Facts before Setting the Specifications," Dr. Toulouse emphasized the need to study a problem carefully before acting upon it. Every business is both a buyer and a seller, and therefore should be interested in specifications for what it buys as well as for what it sells. Statistical methods for finding facts preclude errors in specification writing.

Mr. Edmund Lusas honored. At the November meeting Mr. Edmund Lusas, University of Wisconsin student and holder of one of the three General Foods Fund Fellowships, was officially presented with this distinguished award. The General Foods Fund Fellowship carries with it an honorarium of $4000 per annum and is given to outstanding students in the field of food science.

PITTSBURGH . . .

The 30th official meeting of the Pittsburgh Section of the Institute of Food Technologists was held on Tuesday evening, October 2, 1956, at the Royal York Apartments dining room. Following a pleasant social hour and a fine dinner, the meeting was called to order by the Chairman, Dr. C. R. Stumbo. The members selected by the executive committee to head the various section committees for this year were introduced by Dr. Stumbo. They are as follows:

Membership Committee—A. M. Rosenberg, Standard Can Co.
Finance Committee—J. E. Phillips, H. J. Heinz Co.
Entertainment Committee—A. W. Johnson, Stoner-Mudge Inc.
Publicity Committee—Dr. B. R. Suri, Calgon, Inc.

Col. Charles S. Lawrence, Executive Secretary of IFT, was introduced to the members by the Chairman. Col. Lawrence spoke of the plans for the '57 Convention in Pittsburgh and of the progress which has been made to date by the national headquarters.

Dr. I. J. Hutchings, General Chairman for the '57 Convention, gave a brief resumé of the progress which the local committees have made. He also mentioned the fine cooperation which exists between the Pittsburgh Section and IFT headquarters in Chicago.

Training of Food Technologists Discussed. Dr. Emil M. Mrak, head of Food Technology Dept., University of California at Davis, California and President-Elect of IFT, was introduced by Dr. Stumbo. Dr. Mrak as current president-elect discussed briefly the forthcoming '57 Convention. He offered his full cooperation to the Convention Committees and commented on the energetic appearance which the Pittsburgh Section presented to him.

Dr. Mrak's topic was "Concept of Food Technology at the University of California." He presented the history of the present facilities from the beginning with

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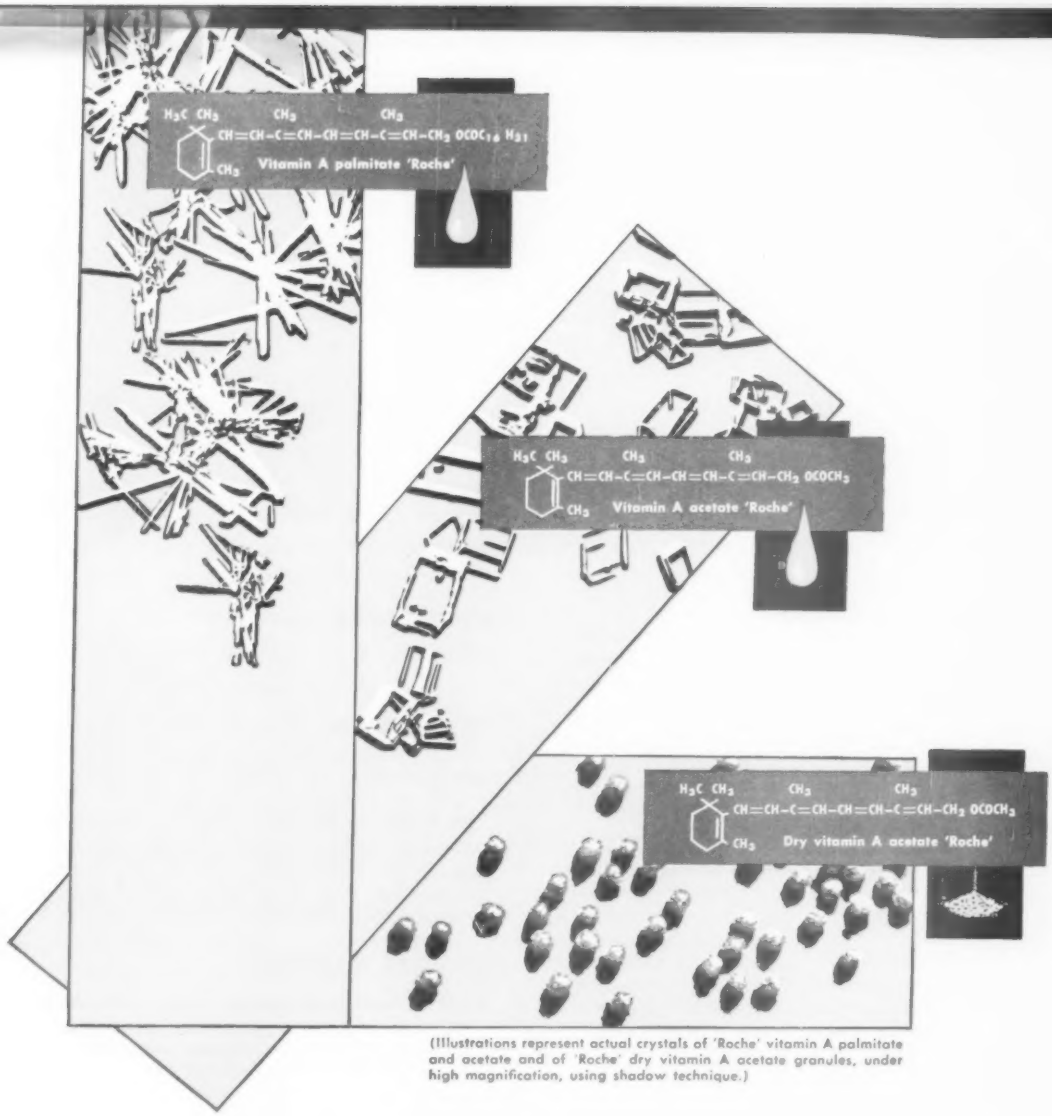

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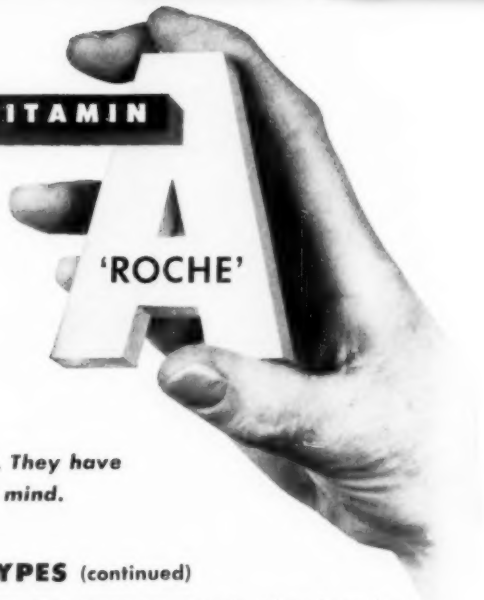

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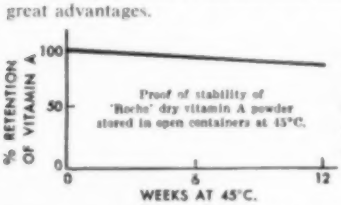

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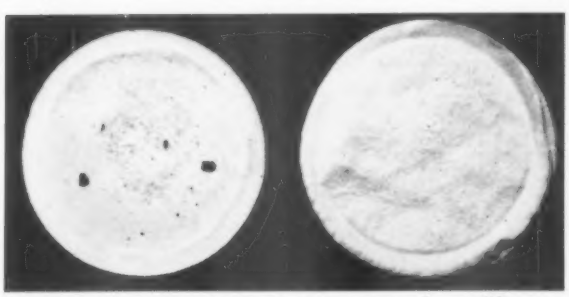
Are you using the right salt?

The grain size and rate of solubility of salt has an important effect on your product. That's why



Unretouched photograph of actual filter test shows difference in purity and cleanliness between a leading granular, cube-like salt (left); and Diamond Crystal Flake Salt (right).

Notice how impurities in the granular salt used discolored the corn on the left—while pure Diamond Crystal has protected the golden appeal of the corn at right. Which brand do *you* think the housewife would buy again?

Diamond Crystal Flake Salt is precision screened into a wide range of grain sizes to meet the most exacting *individual* requirements of your product.

Send for free analysis

If you are not sure that the salt you're using is suitable for your product, send a sample of it with the coupon below to Diamond Crystal. The salt will be given a careful laboratory test and the results forwarded to you free of charge.

Mail this coupon for free salt analysis

Technical Department FT
Diamond Crystal Salt Co., St. Clair, Michigan

I enclose a sample of the salt I now use. Please have it tested and send me the report free of charge. I would also like information on special Diamond Crystal Salts made for my industry.

Name_____

Company_____

Product_____

Address_____

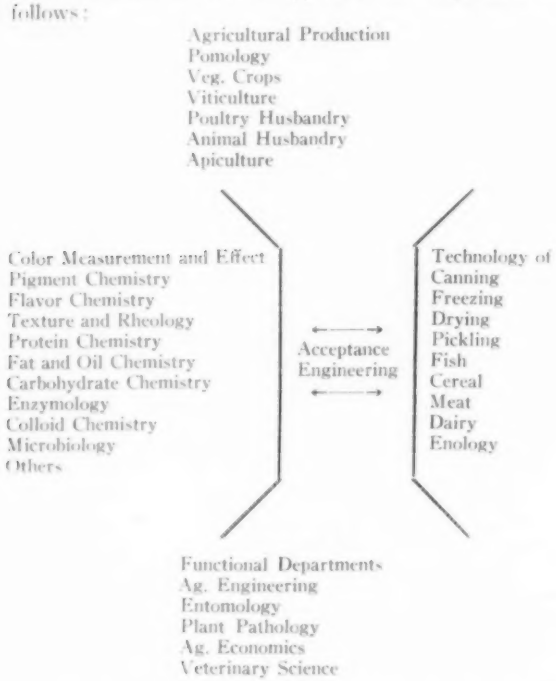
City_____ State_____

Roche Ad No. 2699

(Continued from page 18)

the studies in Enology to the diversified program which consumes their energies. Dr. Mrak spoke of the student studies program which overlaps the boundaries of the various science departments and combines the resources of those departments in studies of Food Technology problems.

The research program in Food Technology was discussed and the functional approach was explained as follows:



A number of slides of various laboratories, pilot plant and equipment were shown.

Finally a question and answer session was held. Among other subjects, the group discussed the present education problem facing the food technology departments of the various colleges and universities. The importance of interesting high school students in the food technology field was presented and talked over by the group.

Food Technology Award of $25.00 to the Best Exhibitor at School Science Fair. This year the Pittsburgh Section decided to take part in the School Science Fair and present an award of $25.00 to the student who would present the best exhibit to encourage the advancement of Food Technology. A committee was formed headed by Dr. I. J. Hutchings of H. J. Heinz. The other members were Mr. A. W. Johnson, Mr. V. W. Vaurio, Dr. C. R. Stumbo, and Dr. H. L. Lang.

A polariscope exhibit displayed at the School Science Fair at Buhl Planetarium was the unanimous choice of the committee. An award of $25.00 was presented to Mr. David Burnham of Mt. Lebanon High School, Pittsburgh, Pennsylvania.

A motion was made that the IFT award to the School Science Fair be made an annual award. The motion was unanimously carried out by the members.

NORTHEAST . . . .

The Section's first meeting of the 1956-57 season was held on Saturday, October 6, at the University of Massachusetts Dining Commons, Amherst, Mass. Ninety-eight members and guests were in attendance.

Officers for this year are:

Chairman—Dr. Samuel A. Goldblith, M.I.T.
Vice-Chairman—Mr. F. Leslie Hart, U. S. Food & Drug Administration
Secretary—Dr. Ernest R. Barron, First National Stores, Inc.
Treasurer—Dr. Edward E. Anderson, A. D. Little, Inc.

Role of the Food Consulting Laboratory Defined. Dr. Bernard H. Oser, Vice-President and Director of Food Research Laboratories, Inc., Long Island City, N. Y. featured the meeting with his excellently presented talk on "The Role of the Independent Food Consulting Laboratory in the Food Industries." He pointed out that the large consulting laboratory is in constant touch with the medical, legal, and academic worlds and is frequently brought into contact with the government as a collaborator. It helps to advance the frontiers of science and can be compared with an academic institution in its scope, investigative efforts, and its statements of truth. It operates on the principle of sticking to facts and truth and does not extend itself beyond its specialized competence.

When dealing with a client, Dr. Oser stated that the primary aim is to give the latter not always what he wants but what he needs. This takes the form of discouraging hopeless projects and avoiding those trafficking in fraud. It is further the responsibility of the food consulting laboratory to publish results upon securing a client's permission and be prepared to defend the work done.

Dr. Oser concluded by expressing the opinion that such a laboratory is an excellent training ground for future workers in the food industries.

AUSTRALIA NORTHERN . . . .

Program for year 1956-57. The new Program Subcommittee of the Australian Northern Section for this year has tackled the problem of forward planning with very considerable vim and vigor. Here are the results:

1956

October 24—Factory Inspection of A.G.M. Co. Pty. Ltd.—details see page 1.

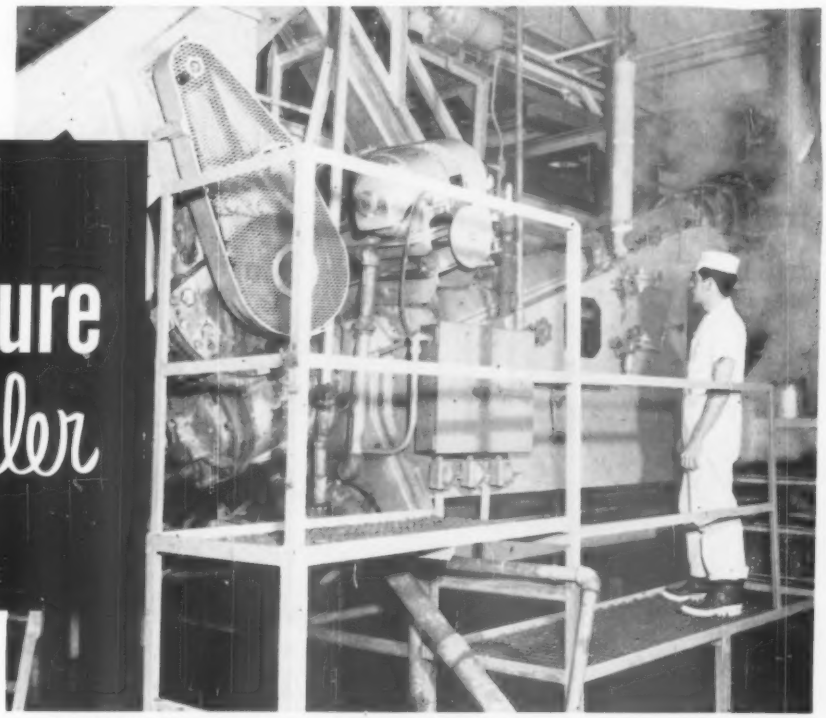
November 30—Friday Morning Trip to Bathurst—Afternoon inspection of Gordon Edgell & Sons Ltd. Bathurst Cannery—asparagus and peas processing—an evening meeting with a speaker from Edgells, subject yet to be decided.

In view of uncertainty about numbers who will attend, members wishing to stay overnight in Bathurst rather than returning directly after the meeting are asked to make early personal bookings for Friday night accommodation in Bathurst.

December—Christmas Social.

(Continued on page 26)

Hi-Pressure *steam peeler*



Typical FMC Steamer preparing fruits and vegetables for *Gerber's Baby Foods* at their Oakland, California plant.

Makes Short Work of Tough Skins

It takes an FMC Continuous High Pressure Steamer, with automatic heat penetration control, to really loosen up the tough ones. Such vegetables as carrots, beets and potatoes (certain fruits, too) are quickly and uniformly exposed to steam pressures up to 120 P.S.I.G., which make the job of skin elimination easy, fast and thorough.

Built for various capacity requirements, this machine provides a yield of 10% or more over other methods of loosening skins. As an example of output, carrots are processed at 5 or more tons per hour under 25 to 30 seconds exposure to steam pressure. In addition, there's an extremely low waste factor, there's no damage to sub-surface nutritional layers, and continuous operation reduces the manpower normally required on non-automatic lines.

Want more information? Just mail the coupon today, or call your nearest FMC representative.

Improved model boasts many features, including adjustable condensate removal unit; rigid, large diameter turret shaft; hard, smooth plate-stock liners; 1¼" heavy duty pressure-resisting firebox side plates. Built to A.S.M.E. code for up to 120 lbs. pressure.

fmc — Food Machinery and Chemical — Key to food equipment

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General Sales Offices:
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Food Machinery and Chemical Corporation
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☐ Please send me a copy of your Bulletin on the *fmc* High Pressure Steam Peeler.

☐ Have your representative call. 522-11

Name _____ Title _____

Company _____

Address _____

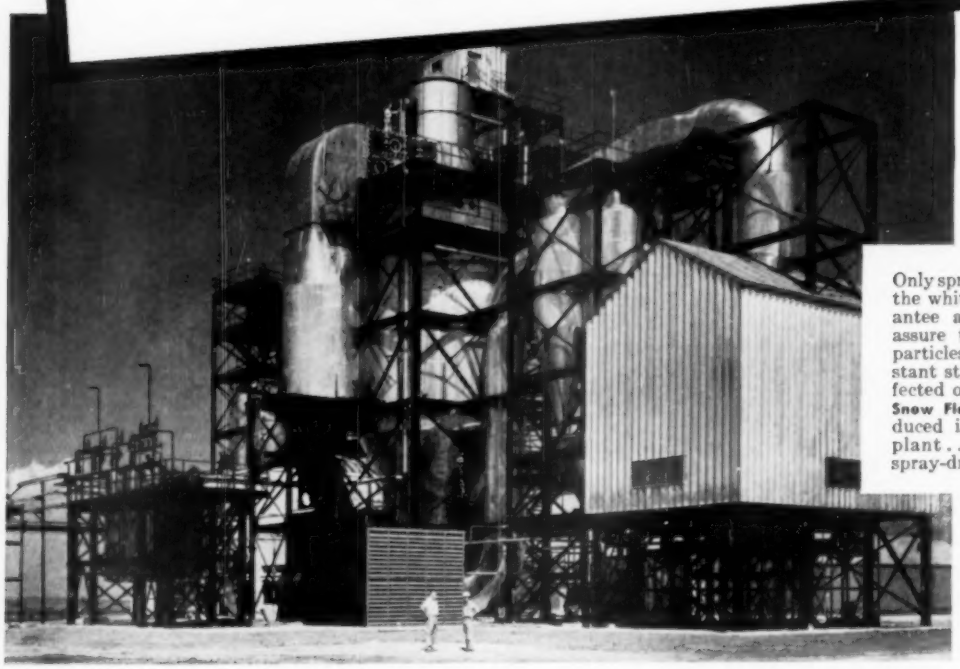
City _____ Zone _____ State _____

NOW! *A completely new food ingredient . . .*

SnowFlake®

ONLY **SNOW FLAKE** INSTANT STARCH GIVES YOU ALL THESE **IMPORTANT ADVANTAGES**

1. Completely pre-cooked under rigidly controlled conditions.
2. Pure, all-white, flavor-free cereal starch.
3. Fine particles of uniform size—flows freely.
4. Disperses evenly in liquids and solutions.
5. Low moisture content means greater stability.
6. Thickens instantly and completely.
7. Compatible with other food ingredients.
8. Assures superlative full-bodied smoothness.
9. Inherent viscosity control for easier reconstituting of dry mixes.



Ultra-modern Spray-Dryer at Corn Products New Corpus Christi Plant

Only spray-drying can preserve the whiteness of starch, guarantee a stable product and assure the fine, uniform-size particles so essential to an instant starch. Tested and perfected over a period of years, **Snow Flake** is now being produced in this newly erected plant . . . America's first for spray-drying starch.

Instant Starch

Pre-cooked, spray-dried to set new standards for instant starch:

- **Greater purity**
- **Faster thickening**
- **Flavor-free**
- **Superior reconstituting agent**

SNOW FLAKE—the world's first spray-dried instant milo starch available in commercial quantities—provides a new standard of purity, stability, quality and convenience. Ideal for instant puddings, frozen and dry mixes, soup and gravy powders, sauce bases, dessert preparations, confectionery products, bakery toppings, salad dressings and other foods, **Snow Flake** opens up almost limitless possibilities for the progressive processor. Consider these major advantages:

GREATER PURITY . . . because **Snow Flake** Instant Starch is spray-dried, comes into contact with nothing but clean, pure air and sanitary, stainless steel.

FASTER THICKENING . . . because **Snow Flake** Instant Starch is pre-cooked, and because spray-drying produces finer, more uniform particles which dissolve more quickly.

FLAVOR-FREE . . . because spray-drying draws off moisture more quickly, with no danger of harmful effects to which starches are subjected in roll-drying.

SUPERIOR RECONSTITUTING AGENT . . . requires less critical measurement of water to produce satisfactory gelation in reconstituting dry mixes.

ASK THE MAN FROM CORN PRODUCTS—His experience and knowledge of the food field are available. He'll be glad to give you additional information, and help you utilize new **Snow Flake** Instant Starch to best advantage.

CORN PRODUCTS REFINING CO.

17 Battery Place, New York 4, N. Y.

(Continued from page 22)

1957

January 26-28 or February 2-4—Three (3) day Inspection of Snowy River Scheme. Leave Sydney Friday evening January 25 or February 1 by air for Cooma where we stay overnight. Snowy River Authority takes over party Saturday A.M. until departure Monday P.M. for Sydney, again by air. Cost £12 to £13 including air fare plus possible £2 for Friday night stayover in Cooma before Snowy River Authority takes over party.

March—A talk by Dr. Keith Farrer, Chairman, Southern Section, who visited America this year.

April—Afternoon visit to Toohey's Brewery.

May—Conjoint Meeting at C.S.I.R.O. Homebush with Dietitians Association.

July—A talk by Professor Hunter of the Sydney University.

September General Meeting

A most successful meeting was held on September 24 at the Food Trades School, East Sydney Technical College. On the catering side, Mr. Don Grover, apologised for something that went astray in the College's kitchen which made the buffet dinner, a little "thin" as to quantity. At the subsequent business meeting (distinct from the dinner!), interesting and "down-to-earth" talk on "Soil Micro-Organisms in Relation to Food Production."

The number and quality of the questions and answers which followed the talk should have reassured Professor Vincent that the Institute and the Meeting really appreciated his subject and how he delivered it. Thirty-nine members and friends were present.

MARYLAND . . . .

The Section met on Friday, October 12. After dinner, the meeting was addressed by Dr. John M. Sharf, Director of Research of the Armstrong Cork Company at Lancaster, Pennsylvania. Dr. Sharf spoke on, "The Effects of Nuclear Explosion on Packaged Food Products." His talk described the Civil Effects Test, carried out at Los Alamos in 1955, to determine the effect of atomic explosions on civilian products and housing. In this test, Dr. Sharf worked with Dr. Laug of the U. S. Food and Drug Administration. Other members of this Section who played a part in the test were Messrs. C. A. Greenleaf and James Reeves of the National Canners' Association.

What a Nuclear Explosion Does to Packaged Food. As a part of the test, twenty tons of assorted packaged foods were coded and placed in different lots, at various distances from ground zero of the nuclear explosion out to a radius of two miles. These were housed in several types of conventional and unconventional civilian structures. After the explosion, the foods were examined for damage and suitability for consumption.

At a radius of two miles all foods showed safe levels of radioactivity, even though windows and doors were broken out of brick houses at this point. At a radius of one mile, brick homes were completely destroyed, but food in unopened containers remained safe. Even fresh food, stored in refrigerators which were not opened by the force of the blast, was still satisfactory. At one-quarter of a mile radius, the radioactivity of most foods was still low enough to permit their use for emergency feeding.

The effect of high neutron bombardment was tested by means of cases of assorted foods buried in trenches under three inches of earth. The tests showed that only those foods containing sodium chloride and phosphorus were dangerously affected. Some tin containers retained excessive radioactivity. Foods, adversely affected in this phase of the test, were milk, beans, sea foods and sausages. In general, the chemical effects of exposure, so close to ground zero, were as follows:

Water—broke down to give hydroxyl ions and peroxides.
Carbohydrates—were degraded into a wide assortment of end products.
Sucrose—yielded reducing sugars.
Proteins—were degraded to amino acids.
Amino Acids—deaminated to give ammonia.

Dr. Sharf concluded his discussion with some observations on atomic power, plus fission and fusion reactions.

PHILADELPHIA . . . .

The first fall meeting was held at Schmidt's Brewery on October 2, with an early start at 4:00 P.M. In small groups the IFT members were conducted through this modern plant to observe the various operations and to view a film on the making, packaging, and storage of beer. For refreshment the members were invited to partake in the taste panel of the finished product.

Presentation on "How Beer Is Made." After dinner at the Brewery Tavern, Mr. Hipp, Brewmaster of Schmidt's Brewery delivered an interesting illustrated lecture on "Beer Making." He presented the historical phase of the subject starting with evidence depicting its beginning in the biblical times, through the middle ages and its introduction to America. With much detail, the speaker explained the various ingredients used, the chemical, physical changes brought about by the addition of each ingredient and the various steps in the process.

With a background of wide practical experience and academic training Mr. Hipp was fully qualified to clearly present both the practical (the art) and the technical (the scientific) aspects of beer manufacturing.

PERSONNEL

DR. RAPHAEL O. WAGENAAR, formerly affiliated with the Food Research Institute of the University of Chicago, has accepted a position with the Research Laboratories of General Mills, Inc., Minneapolis, Minnesota. Dr. Wagenaar, an Associate Editor of *Food Research*, has specialized in the field of bacteriology as it pertains to foods. One of his recent investigations concerned the effects of radiation on *Clostridium botulinum* spores experimentally inoculated into cheese.

They VAPORIZE tinplate to improve it

Although this may look like a peaceable scene, it's not. The instrument shown above — an emission spectograph—vaporizes a sample of metal in a high voltage. This is an important piece of testing equipment in United States Steel's Applied Research Laboratory.

By vaporizing small samples of metal, the emission spectograph performs one step in ascertaining types and amounts of constituents in a given metal. By controlling the composition of the steel, it is possible to attain the most ideal type of steel strip for tinplating purposes. The finest quality steel means finer tinplate, thus, better protection for products packed in tins.

The emission spectograph is only one step in many taken by United States Steel research chemists in the constant search to improve tinplate for canners and packers throughout the world.

USS TINPLATE

UNITED STATES STEEL CORPORATION
525 William Penn Place Pittsburgh 30, Pa.

UNITED STATES STEEL

ANNUAL MEETING ITEMS...

LAST CALL FOR ABSTRACTS OF PAPERS FOR PITTSBURGH IN '57!

December 15, 1956, is the due date for submission of abstracts of technical papers to be presented at the Seventeenth Annual Meeting of IFT in Pittsburgh, May 12-16, 1957. Submit abstracts directly to the appropriate session chairmen (see FOOD TECHNOLOGY, September, 1956, pages 14-18). In case of doubt as to the appropriate session, your abstract should be sent to one of the Co-chairmen of the Technical Program Committee, Dr. R. E. Buck or Dr. C. R. Stumbo, Food Research Dept., H. J. Heinz Co., Pittsburgh 30, Pennsylvania.

December 15, 1956 is necessarily the final deadline owing to the fact that the Pittsburgh Meeting is being held in May, a month earlier than the date of previous Annual Meetings.

FUTURE MEETINGS FOR FOOD TECHNOLOGISTS

1957

January 21-24	Annual Winter Meeting of the National Macaroni Manufacturers Association, Flamingo Hotel, Miami Beach, Florida
February 12-14	Technical School for Pickle Manufacturers, Kellogg Center, Michigan State University, East Lansing, Michigan
February 15-17	Institute of American Poultry Industries 28th Fact Finding Conference, Municipal Auditorium, Kansas City, Missouri
February 26-27	Fifth Annual National Dairy Conference, Kellogg Center, Michigan State University, East Lansing, Michigan
April 23-25	Annual Meeting of the Research and Development Associates, Food and Container Institute, Inc., Jefferson Hotel, Richmond, Virginia
May 12-16, '57	**Institute of Food Technologists, Seventeenth Annual Meeting, Pittsburgh, Pa.**

An open invitation is extended to readers of FOOD TECHNOLOGY to send in to the Editorial Office, 11606 South Bell Avenue, Chicago 43, Illinois notices of annual or national meetings of interest to food technologists.

BOOKS . . .

THE CONDENSED CHEMICAL DICTIONARY, 5th ed., completely revised and enlarged by Arthur and Elizabeth Rose. Reinhold Publishing Corporation, New York (and Chapman and Hall, Ltd., London) 1956.

It is a commentary upon the intensive and extensive scientific and technological effort of recent years to call a tome which contains 1220 double-column pages and 30,000 entries a "condensed" compilation of the vocabulary and nomenclature of chemistry. The first edition of this widely known work was compiled by the late Francis M. Turner and published in 1919. The second and third editions were prepared with the able assistance of Thomas C. Gregory. The fourth and fifth editions were accomplished by Arthur and Elizabeth Rose of State College (now University Park) Pennsylvania. Between the fourth edition and the fifth or present edition five years have elapsed—an interim which the Roses devoted to intensive revision. This is evident in the increase in the vocabularies of fields of current interest, for example, that of radiochemistry.

THE CONDENSED CHEMICAL DICTIONARY is addressed to the chemist but the technical man in any of the natural sciences, the engineer, and even the layman with a modest background in things chemical can go to this book for quick answers. The definitions are clearcut and simple, being categorized into *properties, typical specifications, derivations, grades, containers, method of purification, uses,* etc. The entries appear in a straight alphabetical order. The user can quickly understand the arrangement of the vocabulary by consulting page xix, which describes the plan followed.

Any attempt to comment on the subjects covered in this compilation of 30,000 terms is doomed to be unsatisfactory and incomplete. The vocabulary is drawn from the field of applications as well as the laboratory and therefore not only new chemicals but new uses of chemicals are listed. Adhesives, plasticizers, engineering materials, antibiotics, nuclear terminology, and dozens of other special nomenclatures are included. So recent a word as "neutrino" is listed and explained as is "neatsfoot oil" which, in case you were not aware of it, is not a trade name but only the common name for bubulum oil.

A number of conveniences add to the practical usefulness of the CONDENSED CHEMICAL DICTIONARY—a thumb index, for example, which no dictionary or handbook of this size should be without. An alphabetical list of manufacturers, with their addresses, should be a boon to the purchasing agent with a need to buy quick, for instance, Horse Head Zamak or for that matter Horse Head Zilloy. Regulations for the transportation of explosive are given and also safety information.

It is apparent, without elaborating the point, that this is a useful and practical dictionary for the food technologist. As for trade-name products of interest to the food technologist, most of the suppliers to the food industry are represented and hence definitions of the adjuncts and additives used in food manufacture are readily available. As for the chemicals and the techniques of chemistry as they apply to food, these, too, are present to the degree permitted in a CONDENSED CHEMICAL DICTIONARY. The "degree permitted" can be regarded as very considerable.

MARTIN S. PETERSON
Chicago, Illinois

More Brilliant
than nature's own!
Helping food processors to add the tinge of color that improves upon Nature's own hues has been our business for over 50 years.
We offer a long line of Primary Colors and Blends, produced from basic raw materials wholly within our modern Buffalo plant. Each is standardized within remarkably close limits for uniformity of shade, pure-dye strength and composition. No higher standards of excellence can be consistently maintained.
For uniform color in your finished goods—regardless of season or climate or variations in your incoming foodstuffs-always specify National Certified Food Colors.
Write for your copy of the informative National Certified Color Catalog giving helpful information on blends for popular food-color shades, suggestions on the preparation and care of stock solutions for various food products and other useful data.
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FOOD INDUSTRY TOPICS . . .

. . . by Norb Leinen

. . . in the public interest

Food technology students at Rutgers University should receive added inspiration and learning from a program recently announced by Dr. Walter A. Maclinn, chairman, Department of Food Technology. This involves bringing retired industrial food technologists and emeritus professors of food technology to the campus. These elder statesmen will have the title of coadjutant professor. They will receive no salary, but may be reimbursed for travel, meals, housing, etc., for themselves and wife, and will be entitled to the rights and privileges of regular University staff members. Appointments, for 2 to 8 weeks, will be made by the dean of Administration, Dr. Albert E. Meder, Jr., on recommendation of Dr. Maclinn and Dr. Wm. H. Martin, director of the Agricultural Experiment Station. Funds to finance the program have been and are being raised from industrial sources.

◆ ◆ ◆

The nation's first graduate seminar in food packaging has been initiated by the Food Engineering Department at Illinois Institute of Technology, Technology Center, Chicago 16, Ill. Students, the majority of whom are engaged professionally in food packaging technology, meet weekly with a prominent packaging executive and discuss problems in his specialty. IIT hopes to make this seminar a regular part of its Evening Division program. Inquiries should be directed to Prof. Milton E. Parker, director, Food Engineering Department, IIT.

◆ ◆ ◆

People are the number one concern of the American business executive, according to a survey by American Management Assn., 1515 Broadway, Times Square, New York 36, N. Y. The survey of 214 top and middle management executives brought out that ability to work with people is the quality most needed by an executive; that the greatest rewards—and also some of the worst headaches—for a manager lie in dealing with people; that human relations and the humanities are the subjects they wish they had learned more about at school. The "average" respondent works for a firm having 14,400 employees, is just over 45 years of age, and earns between $20,000 and $30,000 a year. Other highly prized qualities in the human relations area are leadership ability, willingness to listen to other people's ideas, and ability to delegate work to others. Ranked second highest is integrity; third, decisiveness. Other character attributes considered important are courage and self-confidence, perseverance, and humility. Intellectual abilities are less frequently mentioned—perhaps, states the survey—because the respondents take them for granted.

◆ ◆ ◆

A growth of 300 percent in national retail sales of frozen foods within 10 years was forecast by Nathan Cummings, board chairman of Consolidated Foods Corp., Chicago, in his keynote speech before the Central States Frozen Foods Association at the Sheraton Hotel, Chicago, October 19. Pointing out that 25 million of the nation's 43 million families now are regularly buying frozen food items, he stated that the present 5% of all grocery sales in frozen items will rise to 20% by 1966, or well over $7 billion. He also noted that mergers and upgrading of quality standards through national brands is improving production and marketing methods and will stabilize consumer acceptance of frozen foods at a higher level. Admitting the advantage of large companies in obtaining capital and professional management, Mr. Cummings insisted that the importance of small food companies was still secure, "for they are able to do many things faster and more efficiently than a large organization."

◆ ◆ ◆

Kenneth D. Jacob, president of the Association of Official Agricultural Chemists, announced establishment of the Harvey W. Wiley Award for analytical methods at the Association's 70th annual banquet on October 15. The award honors the memory of the founder of the Federal pure food and drug law, who was also one of the founders of the Association. The annual award, which carries a cash prize of $500, will be presented to the scientist or group of scientists who makes an outstanding contribution to development of methods of analysis of foods, cosmetics, drugs, feeds, fertilizers, pesticides, and soil, as well as for methods in general analytical chemistry. The first award will be given at the 71st annual meeting of the Association in October 1957. All scientists, whether members or non-members of the A.O.A.C., are eligible. A.O.A.C. address is Box 540, Benjamin Franklin Station, Washington 4, D. C.

◆ ◆ ◆

Winners of the first two in a planned series of Toni-Gillette Fellowships for graduate chemistry students were announced recently. Arthur M. Wilson, Pleasant Beach, N. J., was named to receive the 1956-57 award at Northwestern University. John Anthony Kreuz, Orchard Park, N. Y., was selected to receive the research grant at Notre Dame University. Both students, chosen by the faculty members of their respective universities, are studying for a Ph.D. in chemistry. Wilson was graduated from Trinity College in Hartford, Conn., and Kreuz did his undergraduate work at Saint Bonaventure University, Olean, N. Y. The Fellowships, providing $3,500 annually to each institution, are used to support the work of the award winner, and can be used in part for any purpose within the discretion of the school to offset its administrative expenses.

◆ ◆ ◆

Chocolate and candy sales for the first 7 months of 1956 were 7% ahead of the same period last year, announced Philip Gott, president, National Confectioners' Assn. The biggest increase, namely 16%, was in terms of packaged goods retailing at from 50c

(Continued on page 32)

Season's Greetings!
Robert S. Whiteside, President
William K. Clark
Vice Pres.—Sales
Keith M. Baldwin
Asst. Sales Mgr.
Dr. R. C. Isherwood
Vice Pres.—
Edward F. Mueller
Asst. Sales Mgr.
Dr. J. K. Krum
Asst. Tech. Dir.
L. R. Patton, Jr.
Asst. Sales Mgr.
Sylvester A. Ryan
Asst. Sales Mgr.
W. J. Davis
Buffalo
K. F. Stromstad
Minneapolis
Michael Padley
New York
Louis Petta
New York
Dan E. Smith
Washington, D. C.
Lyle P. Cermony
Minneapolis
Gordon W. Weed
Williamsport, Pa.
Lee F. Sotlich
Los Angeles
H. H. Bonham
Winnipeg
J. D. Stone
(Consultant)
Toronto
R. Steele Sherratt
New York
R. M. Reese
New York City
Paul C. Allison
Ore.
C. R. Myers
Chicago
H. G. Morgan
Boston
D. R. Lewis
Kansas City
Warren Keller
Mgr., Flour Service Div.
Kansas City
Paul A. McGrath
Kansas City
W. O. Edmonds
St. Louis
J. L. Campbell
Chicago
Jack A. Revord
Chicago
C. L. Chapin
Kansas City
D. L. Nunn
Kansas City
W. Quincy Isaacs
Kansas City
Jim Doty
(Consultant)
Kansas City
L. L. McAninch
Kansas City
Jack Bozman
Atlanta
Polly Bancraft
Dallas
Mrs. Elaine Thompson
Dallas
Sterwin Chemicals Inc.
Subsidiary of Sterling Drug Inc.
1450 Broadway, New York 18, N. Y.
IN CANADA:
Sterwin Chemicals Of Canada Ltd.
1019 Ellis Street W., Windsor, Ont.
To all our friends, our sincere wishes for a very Merry Christmas and a Happy and Prosperous New Year.
R. S. Whiteside
President
Vitamins • Enrichment Concentrates • Vanillin • Fortified Flour Colors • Vitamin Feed Premixes • Flour Bleaching And Maturing Agents • Sanitizing Agents

(Continued from page 30)

to 99c per pound, he stated, whereas the sale of bulk goods decreased 2%. Mr. Gott called attention to the fact that production of beef and veal had increased 12.5% and pork 12.9%, whereas egg production had dropped 11.7% and potato production 40.5%. Although candy consumption is on the increase, industry profits are still very low, he reported. He added that the annual NCA Financial Operations Survey of the Confectionery Industry showed that cost of materials to the typical manufacturing retailer increased more than 2% in 1955 over 1954, but in spite of this, operating profit of confectionery manufacturing retailers before taxes was slightly increased.

. . . *things new under the sun*

Poultry processors and retailers will have a new ally soon with an antibiotic formulation designed to extend freshness time of poultry 50–100%. Following official recognition of Food & Drug Administration acceptance of the product in the October 23 *Federal Register*, Chas. Pfizer & Co., Inc., 630 Flushing Ave., Brooklyn 6, N. Y., announced availability for immediate sale of Biostat-PA. Containing 20% oxytetracycline, the broad spectrum antibiotic will be added to chill tanks during the processing of ice-chilled whole poultry. A unique advantage for the processor is the material's high solubility. It can be added directly to the chill tank water and quickly dispersed throughout the medium. For the retailer, the new extension of freshness time furnishes obvious inventory advantages. Biostat-PA, to be marketed through Pfizer's Chemical Sales Division, will be supplied initially in one package size, a two-kilogram (4.4 lb.) metal can with a polyethylene film liner. The label of the container will bear complete instructions for use. Labeling of processed poultry will be left to the discretion of processors. However, inclusion of the statement, "oxytetracycline added to retard spoilage" is required by Government regulations.

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A new meat-curing adjunct giving substantial savings over the cost of ascorbic acid and sodium ascorbate for curing sausage and primal cuts is announced by Merck & Co., Inc., Chemical Division, Rahway, N. J. The product, sodium isoascorbate, Merck, sold under the trademark 'Neo-Cebitate,' has the approval of the Meat Inspection Branch of USDA for use in cured pork and beef products. 'Neo-Cebitate,' physically similar to ascorbic acid and sodium ascorbate, is a white, crystalline powder which is free-flowing, non-dusting, non-caking, and water soluble. Although 'Neo-Cebitate' replaces both ascorbic acid and sodium ascorbate in meat applications, Merck will continue to supply these products to the meat industry. 'Neo-Cebitate' also can be used to replace ascorbic acid and sodium ascorbate as anti-oxidants in frozen foods, fruit juices, and beer.

Merck also announces availability soon of 'Accel,' consisting of live cells prepared in dry form for production of fermented sausage. The dry lactic acid starter culture (Pediococcus cerevisiae), originally developed by the American Meat Institute Foundation, reportedly reduces process time, lessens product failures, and improves product flavor, texture, and color.

◆ ◆ ◆

The Canadian government has cleared use of "Acronize" to halt growth of bacteria responsible for deterioration of fish from the time it is caught to the time it reaches the consumer. The process, developed by American Cyanamid Company, 30 Rockefeller Plaza, New York 20, N. Y., employs the antibiotic Aureomycin (chlortetracycline) to keep fish fresh for at least one week longer than is possible with ordinary refrigeration methods alone. Acronize has been approved in the U. S. for use on poultry. Additional formulas now are being developed for use on red meat and other perishable food products. Indications are that Acronize will prevent a major part of the bacterial spoilage which costs Canadian fishermen some 23% of their effort.

◆ ◆ ◆

The first foil package for frozen vegetables is Bencoseal overwrap, produced for the Susquehanna Frozen Food Centers by Shellmar-Betner Division of Continental Can Co., 100 E. 42nd St., New York 17, N. Y. Bencoseal, applied over a plain carton, is a foil-wax-tissue lamination that is heat-sealing, moisture-proof, vapor-proof, and air-tight. Another first for this Susque package is its institutional size. Housewives can use whatever quantity they desire from the 40-ounce package and retain the balance. Also, the vegetables are all individually quick-frozen. Each single pea, bean, etc., is frozen separately before being packed, rather than in a solid block as are many frozen foods. The housewife thus is not restricted to using the full package at one time.

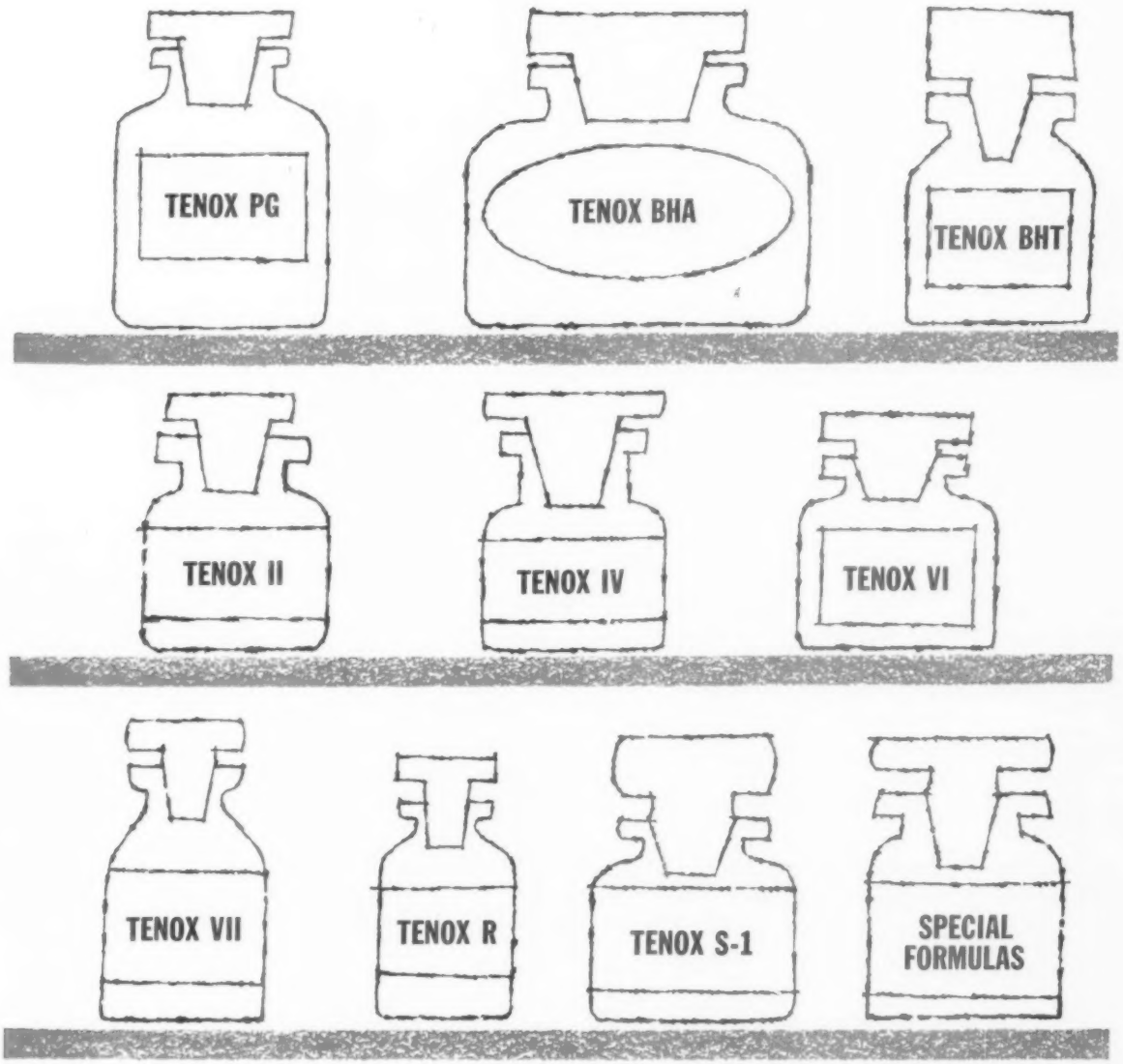
◆ ◆ ◆

High rate of wear on stems and seats in bleed-off valves controlling the flow of chocolate liquor at high pressure in a line of food processing equipment created a problem in maintenance costs which was solved by Kennametal Inc., Latrobe, Pa., through **use of hard carbides at points of excessive wear.** The worn point on a steel valve stem was cut off and a Kennametal Grade K6 nib was butt-brazed in its place. The steel seat was replaced by a Kennametal Grade K6 seat. After 2½ years, the first altered parts are still in service. They reportedly paid for themselves in 3½ months and to date have saved an expense of $388, based on parts alone.

◆ ◆ ◆

A portable belt conveyor equipped with a self-powered elevating device is being introduced by The Colson Corp., Elyria, Ohio. A single-lever control adjusts the angle from horizontal to 45°, and a powered screw automatically locks the conveyor at the desired angle. Available as standard equipment on

(Continued on page 34)



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(Continued from page 32)

the 20- and 22-foot length models, the lever controls a clutch mechanism which raises the unit when the belt moves in a forward position and lowers it when belt is reversed. The 14″ wide, 3-ply duck, rubber rough-top belt will handle items up to 30°. For 30° to 45° operation, cleats are supplied at no extra charge. Capacity is 150 pounds per package or 300 pounds fully distributed. The conveyor also is available in 10-, 12-, 14-, and 16-foot lengths. Elevated discharge heights range from 8′1″ for the 10-foot unit, to 12′7″ for the 22-foot unit.

◆ ◆ ◆

A new commercial lighting fixture that "breathes" cooled air is expected to drastically chop mass air conditioning installation costs. Called the Multi-Vent Troffer, this single-dual-purpose ceiling fixture provides both air distribution and lighting, performing a job that formerly required two separate units. It is adaptable to any drop-type ceiling. Two firms, Pyle-National Co., 1334 N. Kostner, Chicago, and Benjamin Electric Co., Des Plaines, Ill., jointly engineered and designed the new unit which eliminates "busy" ceilings, cluttered with unsightly air-distribution units. The Multi-Vent Troffer looks like a regular recessed fluorescent light fixture. A completely concealed, built-in air diffuser, mounted above the reflector plate, distributes low-velocity air which bypasses the lamps. Estimated cost (based on 5′ by 5′ model) is approximately $1.60 per sq. ft. as compared to $2.00 per sq. ft. for separate lighting and air-conditioning systems.

◆ ◆ ◆

The first commercial use by a U. S. dairy of a new Swedish packaging process called Tetra Pak was announced by Sunrise Dairies, Hillside, N. J. The 3 machines at Sunrise (¾-ounce, 4-ounce, and 8-ounce) simultaneously form and fill milk or cream cartons from a single roll of paper. The paper is being especially made for the process by Crown Zellerbach Corp., 343 Sansome St., San Francisco, Calif. Ten commercial Tetra Pak machines are on order for concerns all across the country, including dairies, ice cream plants, and citrus juice packers.

◆ ◆ ◆

A new process for preparation of pie fillings has been announced by National Starch Products Inc., 270 Madison Ave., New York, N. Y. Utilizing a new instant thickener, Purity Stabilizer No. 37, the process eliminates use of cooking kettles. The thickener simply is added to water with high speed agitation for a few minutes, and then the fruit, fruit juice, and sweetener are added. There is no bruising or damage to the fruit, which retains its original natural color and appearance. Since cooking is unnecessary, the problem of cooling also is eliminated.

Three new adhesives for laminating work also have been announced by National Adhesives Division of National Starch. Rubber-based Resyn 36-6254 is formulated to laminate cellulose acetate butyrate to foil in the production of metallic yarn. "Boilable" flexible containers are being made by laminating reverse printed cellulose acetate to foil with Resyn 76-3930, a vinyl lacquer. For laminating Mylar to metallized Mylar or Mylar to foil, rubber-based Resyn 76-3944 is being used.

◆ ◆ ◆

A tear-strip of tough plastic material (Mylar) laminated to an easily removed strip of aluminum instantly opens the new all-aluminum casserole-type refrigerated or frozen food container developed by Reynolds Metals Co., 2500 S. 3rd St., Louisville, Ky. The lid is tightly crimped and sealed by a new method, with specially-designed closing equipment which will be made available by Reynolds in various models, ranging from hand-operated machines to high-speed automatic equipment. The lids are attractively color-printed by Reynolds. The container now being produced is the popular 12-fluid-ounce size, measuring 4½″ by 5½″. It soon will be available in 14-fluid-ounce size. The same lid fits all sizes.

◆ ◆ ◆

A new line of acid- and alkali-resistant greases for problem applications in the food processing, brewing, chemical, plastics, and other industries is announced by Keystone Lubricating Co., Philadelphia. Known as the Keystone 5P line, the lubricants provide protection against over 100 corrosive agents and solvents and, in addition, prevent leakage, preserve packings, protect equipment and floors, and lower operating and maintenance costs. The line consists of three types covering a range of operating temperatures from 0° to 350° F. They have a smooth, non-fibrous body, are pale amber to light cream in color, are made in four consistencies, and have an ASTM penetration range of from 200 to 350. Write the firm c/o Harris D. McKinney, Inc., 12 S. 12th St., Philadelphia 7, Pa.

◆ ◆ ◆

In anticipation of a possible apricot kernel oil shortage, GRAVITOL, an entirely new blend of tasteless and odorless brominated vegetable oils, and GRAVITOL A, a brominated blend of these oils and apricot kernel oil, now are available at attractive prices on a freight prepaid basis from Sterol Derivatives, Inc., 3626 Medford St., Los Angeles, Calif. These oils possess the same physical properties as Ponderol, brominated apricot kernel oil—minimum specific gravity of 1.34, crystal clear amber color, excellent stability.

◆ ◆ ◆

A complete series of ion exchange resins has been developed by Rohm & Haas Co., Resinous Products Division, Washington Square, Philadelphia 5, Pa., specifically for chromatographic analyses. While chemically identical with standard- and analytical-grade Amberlite ion exchange resins, the new "CG

(Continued on page 40 following technical papers)

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Studies on a Radio-Resistant Micrococcus. I. Isolation, Morphology, Cultural Characteristics, and Resistance to Gamma Radiation[a,b,c]

A. W. Anderson, H. C. Nordan, R. F. Cain, Gordon Parrish and Dennis Duggan
Oregon Agricultural Experiment Station, Corvallis, Oregon

(Manuscript received July 24, 1956)

APPLICATION OF IONIZING RADIATION to sterilization of foods and other materials has led to a number of studies on the radio-resistance of microorganisms. The subject of radiation effects on bacteria in general has been reviewed in a recent symposium by Kelner *et al. (2)*. Proctor and Goldblith *(3, 4)* have shown that the radiation dosages required for destruction may vary with the concentration of cells, type of substrate, temperature, and to a marked extent with the species. Hollaender *et al. (1)* have shown that in addition to the above factors oxygen tension may modify the radiation sensitivity of microorganisms. Some species exhibit high resistance to radiation damage in the spore state, which may account for the prevailing belief that only bacterial spores offer greater resistance to radiation destruction than vegetative cells.

During studies at the Oregon Agricultural Experiment Station on the effect of gamma radiation on sterilization of meat (under contract with the Quartermaster Food and Container Institute) a bacterial species was isolated from meats exposed to dosages of 2×10^6 and 3×10^6 roentgen equivalent physical (rep). The first indication of spoilage in irradiated meat was a swelling in cans stored under incubation temperatures of 72 and 100° F. (22 and 38° C.). The spoilage was characterized by CO_2 production and a very slight degree of proteolysis in the unopened can, followed by marked proteolysis at room temperature if the can was opened for 48 to 96 hours. The presence of the radio-resistant organism was confirmed by procuring meat from the same source as well as culturing the organism in various forms of liquid and solid media. These were irradiated at two radiation sites which included cobalt 60 and atomic fission by-products. Exposures to various dosages demonstrated that this microorganism, a non-sporeforming type, survives 4×10^6 rep in ground meat and tryptone glucose yeast extract (TGY) broth, and up to 6×10^6 rep on TGY agar slants. The far reaching significance of an organism capable of such a high degree of radiation resistance consequently prompted further studies on its taxonomy, cultural characteristics, and physiology.

EXPERIMENTAL

One-pound samples of ground beef (85/15 lean/fat ratio) were placed in No. 2 (307 x 409) cans. The ground beef had been procured from the same source from which radio-resistant microorganisms had been previously isolated and cultured. Forty No. 2 cans of meat were prepared for shipment to each of two radiation sources: The Materials Test Reactor (MTR) and Stanford Research Institute. One-half of the cans, for each source, were inoculated with an aqueous suspension of the previously irradiated organisms. The initial count of the uninoculated and inoculated meat samples was 2×10^0 and 14×10^0 organisms per gram, respectively.

Radiation resistance of pure cultures of the previously irradiated organism was determined by irradiating the culture directly on agar slants and in broth medium. For this purpose, the cultures were grown for 48 hours on TGY[d] agar slants or 24 hours at 95° F. (35° C.) in TGY broth modified by the addition of 0.5% N-Z amine (Sheffield Chemical Company). One dozen tubes of the broth and agar slant cultures were sealed, fitted into a No. 2 can and padded with peat moss.

Cans were hermetically sealed, placed at —20° F. (—28° C.) for 24 hours and then shipped to the irradiation sources with dry ice. The can contents received 2×10^6 rep at Stanford and the MTR. The time intervals for the accumulation of these dosages were 19 and 2 hours respectively, at temperatures of approximately 76° F. (24° C.). No attempt was made to maintain the contents of the cans frozen during irradiation. Following irradiation, the cans were refrigerated with dry ice and returned to our laboratories.

Irradiated meat samples were opened aseptically and 10 g. transferred to a sterile blender and mixed for 1 to 2 minutes with 100 ml. of sterile water. Five ml. of the diluted sample were plated in TGY agar, incubated at 95° F. (35° C.) for 72 to 96 hours, and the plates examined for colonies of surviving organisms. The number of surviving organisms for the uninoculated meat averaged 150 radio-resistant organisms per gram. The number of surviving radio-resistant microorganisms were too numerous to count at the dilutions (1:100) used with the inoculated meat.

RESULTS

Isolation and radio-resistance. Examination of ground pork and beef for microorganisms after irradiation at 2 or 3×10^6 rep always revealed a pure culture of a red-pigmented micrococcus. These organisms comprised approximately 0.05 to 0.1% of the total microbial population of the unirradiated meat. Table 1 shows that destruction by radiation, based on the total number of organisms present, approached 99.99%. However, the destruction of radio-resistant micrococci was much lower. Neither spore nor non-spore forms, other than the radio-resistant micrococci, were ever encountered in

[a] Technical paper No. 950, Oregon Agricultural Experiment Station. Contribution of the Departments of Bacteriology and Food Technology.

[b] This paper reports research undertaken in cooperation with the Quartermaster Food and Container Institute for the Armed Forces, and has been assigned number 612 in the series of papers approved for publication. The views or conclusions contained in this report are those of the authors. They are not to be construed as necessarily reflecting the views or indorsement of the Department of Defense.

[c] Presented at the Sixteenth Annual Meeting of the Institute of Food Technologists, St. Louis, Missouri, June 13, 1956.

[d] Composition: Tryptone 0.5%, glucose 0.1%, yeast extract 0.3% and agar 1.5% pH approximately 7.0.

TABLE 2

Effect of dosage of gamma radiation treatment on survival of pure cultures of a radio-resistant micrococcus and Micrococcus Pyogenes var. Aureus

Organism	Suspending medium[1]	Survivors after exposure at following dosage levels									
		Unirrad. control	1×10^6 rep	5×10^6 rep	1×10^6 rep	1.5×10^6 rep	2×10^6 rep	3×10^6 rep	4×10^6 rep	5×10^6 rep	6×10^6 rep
		no./ml.	*no./ml.*	*no./ml.*	*no./ml.*	*no./ml.*	*no./ml.*	*no./ml.*	*no./ml.*	*no./ml.*	*no./ml.*
Radio resist. micrococcus[2]	TGY broth	5.1×10^7	3.6×10^7	2.6×10^7	2.2×10^7	2.7×10^6	1.1×10^6	2.5×10^5	7.7×10^4	20	0
Radio resist. micrococcus[2]	TGY broth	5.3×10^7	3.6×10^7	2.7×10^7	1.7×10^7	1.2×10^6	1.8×10^6	1.5×10^5	3.8×10^4	10	0
M. pyogenes var. aureus	TGY broth	7.3×10^7	7.2×10^5	5.1×10^5	0	0	0	0	0	0	0
Radio resist. micrococcus[2]	TGY agar slants	4+[4]	4+	4+	4+	3+	3+	2+	2+	2+	1+
Radio resist. micrococcus[3]	TGY agar slants	4+	4+	4+	4+	3+	3+	2+	2+	2+	1+

[1] Media indicated were used for growth and for suspension of organisms during irradiation.
[2] Strain of organism was isolated from previously irradiated meat.
[3] Strain of organism was isolated from unirradiated meat.
[4] Growth indicated by degree of positive sign.

meat after it had been exposed to gamma radiation at levels of 2×10^6 rep or greater.

The level of gamma radiation required for complete destruction of the radio-resistant micrococci appeared to be considerably greater than 3×10^6 rep. Further trials were carried out in which ground beef naturally contaminated with radio-resistant micrococci was exposed to dosages of 4×10^6 and 5×10^6 rep. Pure cultures of the previously irradiated and non-irradiated organism, in broth and on agar slants, were exposed to 1×10^6 to 6×10^6 rep. These results are reported in Table 2.

Micrococcus pyogenes var. *aureus* was included for purposes of comparison. Results indicate that the micrococcus isolated from irradiated meat was 6 to 8 times as resistant to gamma radiation as *M. pyogenes* var. *aureus* under identical conditions of exposure. The radio-resistant micrococcus actually survived the extreme exposure of 6×10^6 rep when irradiated in the form of agar slope cultures. No apparent difference in susceptibility to radiation was discernible between isolates of the resistant micrococcus that had been recovered from irradiated meat and those that were isolated from un-irradiated meat and exposed to irradiation for the first time. Results in Table 2 indicate almost identical recoveries for both strains when irradiated in TGY broth. Both strains exhibited a high degree of resistance when exposed in the form of 48 hour agar slope cultures. Samples of meat which had received dosages of 4 and 5×10^6 rep underwent rapid spoilage when held in the opened can at room temperature. This spoilage was characterized by the development of large numbers of the radio-resistant micrococci accompanied by gas formation and considerable proteolysis.

TABLE 1

Effect of dosage of gamma radiation on survival of radio-resistant micrococci in ground pork and beef

Trial	Average number of bacteria[1] surviving[2] following treatments:		
	Control—no treatment	Irradiated at 2×10^6 rep	Irradiated at 3×10^6 rep
	no./gm.	*no./gm.*	*no./gm.*
1	1,000,000	200	12
2	1,000,000	150	8
3	5,900,000	5,000	550
4	1,700,000	1,500	600
5	1,800,000	370	.....
6	2,400,000	800	.....
7	1,900,000	330	.....

[1] Based on plate count with TGY agar.
[2] Survivors represent one species of resistant micrococcus which comprised approximately 0.05% to 0.1% of total bacterial numbers before irradiation.

Morphology and cultural characteristics. The radio-resistant micrococcus occurred as large spheres which averaged about 2 microns and ranged from approximately 1.5 to 3 microns in diameter. It occurred principally as tetrads and occasionally in pairs or singly.

Cells, in the early stages of growth stained gram positive, while older cells stained gram variable. Capsules were not demonstrated when the culture was grown in broth or on agar. Growth was scanty or in some cases not discernible on plain nutrient broth, beef heart infusion broth, veal infusion broth, or tryptone glucose beef extract agars. Visible colonies developed after 48 hours of incubation at 95° F. (35° C.) on TGY agar. They appeared as small (0.5 mm.), glistening, round, slightly raised and pink or flesh-colored. After one week at 86° to 95° F. (30° to 35° C.) the colonies increased to about 3 mm. in size and the pigment varied from a flesh color to brownish-red or carmine red. After 7 days of growth at 68° to 77° F. (20° to 25° C.) TGY agar slants exhibited moderate, filiform, raised, smooth, glistening flesh-colored growth about 4 to 6 mm. in width along the line of inoculation. TGY broth cultures at 86° F. (30° C.) showed excellent growth in 2 days, characterized by a flocculent precipitate and brownish red color throughout with no visible gas formation. The growth in TGY broth could be accelerated by addition of 0.5% N-Z amine (Sheffield Chemical Co.) and vigorous aeration by means of a sintered glass sparger or in Erlenmeyer flasks on a rotary shaker. Such aerated cultures grown in the N-Z amine modified TGY broth for 6 to 8 hours or more at 86° F. (30° C.) produced bright reddish coloration throughout the medium. After 18 to 20 hours of growth the cells formed a flocculent, red precipitate that settled out on standing.

Physiology. The radio-resistant micrococcus isolated appeared facultative with respect to oxygen; however, as has been mentioned, growth was stimulated by vigorous aeration. Growth and spoilage apparently occurred in cans of meat under essentially anaerobic conditions. Nitrates were not reduced to nitrites. Growth was markedly inhibited by 1% sodium chloride when cultures were grown on TGY agar slants or in broth following the initial isolation. Some fractions of the reddish to brownish pigment produced appeared

water soluble and diffused throughout agar and broth media. Other fractions of the pigment appeared soluble in alcohol or methanol, and did not diffuse into the medium. Slight beta-type hemolysis was evident on blood agar plates after one week of incubation. Fermentation of specific sugars was difficult to evaluate because the organism appeared to utilize various organic medium constituents as a source of carbon. Slight liquefication of gelatin occurred at 86° F. (30° C.). Liquefication occurred only at the surface of the stab and scant growth took place in deeper layers. No visible change and negligible growth occurred in litmus milk cultures incubated at 86° F. (30° C.) for one week.

The radio-resistant micrococcus grew over a wide temperature range. Growth occurred slowly at refrigeration temperatures 41° F. (5° C.). Most abundant growth was obtained at 77° F to 86° F. (25° C. to 30° C.). Growth was excellent at 98° F. (37° C.), but no growth occurred at 113° F. (45° C.). The radio-resistant bacteria isolated from ground pork and ground beef appeared to represent a single species closely related to *Micrococcus roseus* (ATCC 9815) and *Micrococcus rubens tetragenus* (ATCC 186). The latter two appeared similar to the newly isolated radio-resistant micrococcus in morphology, cultural characteristics, and many physiological properties including high catalase activity. They also demonstrated high resistance to gamma radiation, although theirs did not approach the extreme resistance of the new isolate.

DISCUSSION

Radiation resistance in bacteria usually has been associated with species capable of producing spores. However, the micrococcus isolated has shown resistance to radiation greater than any other bacteria previously encountered. The mechanism or protective agency responsible for such remarkable radiation resistance has not been established. Studies are in progress on composition, morphology, fundamental metabolism, and other aspects of the physiology of the organism in order to better understand the mechanism of resistance. One interesting feature in this connection is the high catalase activity characteristic of this species. Actually, catalase production appears greater than for any other bacterial species studied in this laboratory. The ATCC cultures 9815 and 186 also demonstrated higher than normal catalase production but less than the new radio-resistant isolate.

Another significant observation is the similarity in radio-resistance between isolates of the organism from unirradiated and irradiated meat. This indicates that the radio-resistance probably is a stable, inherent characteristic not acquired as a result of one or a few exposures to gamma radiation. Stability of the radio-resistant characteristic is of particular interest from the standpoint of its possible use as a test organism in food or other products subjected to irradiation.

Thus far irradiated and unirradiated strains have shown no significant differences in morphology, pigmentation, metabolism and nutritional requirements. The extremely high catalase production by the radio-resistant species may be of significance as a protective mechanism.

Temperature relationships of the radio-resistant organism are of considerable significance. Extensive growth at 41° F. (5° C.) in meat with consequent spoilage indicates that radiation plus subsequent refrigeration at temperatures above 32° F. (0° C.) may not provide adequate control of its activity in foods. Its facultative nature enables the organism to develop in hermetically sealed containers.

The explanation for the exceptionally high resistance of the organism on agar may lie partly in the nature of substrate irradiated and partly in age of cells undergoing irradiation. Cells streaked on agar slopes were older than those exposed in broth, and preliminary trials suggest a great variation in resistance to gamma radiation between young and old cells. Cells seem to demonstrate about the same order of resistance in meat and broth although age of cells again may complicate evaluation of the results. Age of the cells in naturally contaminated meat is difficult to assess.

Whether or not the radio-resistant micrococcus represents a new species must await further investigation. The fact that the two closely related organisms, *M. roseus* and *M. rubens tetragenus*, showed much lower resistance to radiation, suggests that they are fundamentally different. It is possible that investigations on physiology including metabolic pathways involved may clarify this aspect.

SUMMARY

A radio-resistant micrococcus resembling *Micrococcus roseus* and *Micrococcus rubens tetragenus* has been isolated from samples of ground beef and pork following gamma irradiation dosages of 2 to 3×10^6 rep. Pure cultures of the isolated organism have survived extreme exposures of 6×10^6 rep on agar slopes. This order of resistance was 6 to 8 times that of *Micrococcus pyogenes*, var. *aureus* and greater than that of any spore-forming bacteria tested in this laboratory. Strains of the organism isolated from naturally contaminated unirradiated meat demonstrated the same high order of radiation resistance.

Growth of the organism in irradiated meat or unirradiated meat was accompanied by CO_2 production and slight proteolysis in the closed can and marked proteolysis in the opened can. The organism occurred as gram positive tetrads, and produced a reddish brown pigment in laboratory cultures. Growth occurred slowly in refrigerated samples at 41° F. (5° C.), and not at all at 113° F. (45° C.).

Studies are under way to further characterize the radio-resistant micrococcus and establish its sources and habitat in nature. Investigations also are in progress on metabolism and other properties in an attempt to elucidate the mechanism of resistance.

Acknowledgment

The authors wish to acknowledge the assistance of Dr. P. R. Elliker, Bacteriology Department, for his suggestions during the course of these investigations and in the preparation of this manuscript, and Dr. H. W. Schultz, Food Technology Department, for his encouragement and cooperation. Appreciation is also expressed to Mr. William Sandine for his assistance in the laboratory.

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Chemical Ices for Shrimp Preservation[a]

E. A. Fieger, M. E. Bailey and A. F. Novak

Department of Agricultural Chemistry and Biochemistry, College of Chemistry and Physics and Louisiana Agricultural Experiment Station, Louisiana State University, Baton Rouge, Louisiana

(Manuscript received April 26, 1956)

Recent changes and developments in the shrimp industry have posed new problems in maintaining the quality of shrimp offered to the consumer—for example, the use of larger boats making more extended and farther trips to and from shrimp grounds; the introduction into commercial channels of new species more susceptible to deterioration in refrigerated storage; and the transportation of fresh shrimp to interior cities for processing. The sale of pre-packaged fresh shrimp which in many instances are not adequately refrigerated or protected invites the development of black spot or melanosis as well as other deteriorative changes. The shrimp industry, keenly aware of these problems, is searching for methods which will result in longer fresh storage life for shrimp and for the improvement in quality of the stored product.

If shrimp are stored in dry refrigeration, or if they are otherwise stored without constant contact with water as is achieved by ice storage, melanosis becomes a primary problem *(6)*. Frozen storage is undoubtedly the best method of preserving the quality of freshly caught shrimp, but black spot formation is still prevalent even in this type of storage.

Since freezing and refrigerating equipment in general are expensive to purchase and maintain, the usual commercial practice for storing fresh shrimp, particularly on the trawlers, is to place them in alternate layers between crushed ice. This being the case, it is very desirable to develop better methods of ice storage for this product. Investigations described in this paper and others to follow were undertaken with these objectives in mind, (a) to determine the effect of chemical ices on the ice storage life of fresh shrimp, (b) to study the effect of different chemical ices on the prevention of black spot in ice stored shrimp and (c) to determine the value of several chemical and physical tests as indicators of the relative quality of shrimp stored in various types of chemical and commercial ices.

Fieger and Friloux *(4)* have shown the maximum ice storage period for shrimp before the onset of spoilage is approximately 2 weeks. Since bacterial action is believed to be the primary cause of the rapid deterioration, incorporation of bacteriostatic agents into ice should, in theory, prolong this storage period. Several tests were therefore conducted using ices containing different concentrations of chlorotetracycline as well as other chemicals. The other chemicals usually were added to retard melanosis.

MATERIALS AND METHODS

During the past 18 months, five storage tests were conducted using a total of 12 different chemical ices. These vary as to the chemical used or the concentration of the chemical. Most of these ices were prepared in the laboratory by freezing small increments of the solution in stainless steel pans in a plate freezer at −55° F. (−48° C.) Chlorotetracycline ices (CTC ices) were prepared by a commercial ice plant using Sea Kem No. 9 as the dispersing agent *(10)*.

The shrimp used in these experiments were purchased either directly from trawler owners or from shrimp processing plants. A historical summary of the shrimp and the ices used for their storage is presented in Table I. In all cases, except Test No. 12,

TABLE 1

Test no.	History of shrimp sample	Ices used	Length of storage
8	*Penaeus aztecus*, size count 31-35, caught 36 hours prior to purchase.	(a) Commercial ice (b) CTC ice 1 p.p.m. (c) Sodium bisulfite ice 100 p.p.m. (d) Ascorbic Acid—citric acid (8.9:2) ice—1000 p.p.m.	15 days
9	Mixed *Penaeus setiferus* and *Penaeus brasiliensis*, size count 41-50, caught day of purchase.	(e) Commercial ice (f) CTC ice 5 p.p.m. (g) Sodium bisulfite ice 1000 p.p.m.	16 days
10	*Penaeus setiferus*, size count 26-30, composite from several trawls, stored on trawler from 1 to several days.	(h) Commercial ice (i) CTC 5 p.p.m. plus sodium bisulfite 1500 p.p.m. ice (j) Sodium bisulfite ice 1500 p.p.m. Ices (i) and (j) were prepared by using Sea Kem No. 9 as dispersing agent	15 days
11	*Penaeus setiferus*, mixed size, caught 6 hours prior to purchase.	(k) Commercial ice (l) Acid ice (HCl to pH 5.0) (m) Fran-Kem ice 500 p.p.m. (n) Tannic Acid ice 500 p.p.m.	16 days
12	*Penaeus setiferus*, size count 41-50, headed, washed and iced on trawler by members of the staff.	(o) Commercial ice (p) CTC ice 10 p.p.m. using Sea Kem No. 9 as dispersing agent (q) Salt ice 22,000 p.p.m. consisting of sodium chloride 20,000 p.p.m. plus calcium chloride 2000 p.p.m.	21 days

[a] This study was supported in part by grants-in-aid from Lederle Laboratories Division, American Cyanamid Co., Louisiana Wildlife and Fisheries Commission and the Shrimp Association of the Americas.

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ERRATA, VOLUME 10, 1956

FOOD TECHNOL., *10*, page 179 (1956)

The surname of the third author, presently spelled *Brackenbyer*, is correctly spelled *Brackemeyer*.

FOOD TECHNOL., *10*, page *266* (1956). Under "Experimental", the last sentence under the subhead, "Rations", reads, as published:

"This amount of Aurofac contributed 9 milligrams of chlortetracycline, formerly referred to as Aureomycin, and 9 micrograms of Vitamin B_{12} per pound of feed." This sentence should read as follows:

"This amount of Aurofac contributed 9 milligrams of chlortetracycline (Aureomycin) and 9 micrograms of Vitamin B_{12} per pound of feed."

FOOD TECHNOL., *10* (8) page 40 (1956). Under "Masters and Doctors in Food Technology" the degree taken by M. S. Chan at the University of Massachusetts in June 1956 was not a master's, as published, but a Ph.D.

FOOD TECHNOL., page 424 (1956). In the article by Wick and Cairncross on artificial pepper, lines 11 and 12, right column, were misplaced and appear at the foot of the column. The sentence (lines 11 and 12) should read:

"The melting point, mixed melting point and infrared spectrum were identical."

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water soluble and diffused throughout agar and broth media. Other fractions of the pigment appeared soluble in alcohol or methanol, and did not diffuse into the medium. Slight beta-type hemolysis was evident on blood agar plates after one week of incubation. Fermentation of specific sugars was difficult to evaluate because the organism appeared to utilize various organic medium constituents as a source of carbon. Slight liquefication of gelatin occurred at 86° F. (30° C.). Liquefication occurred only at the surface of the stab and scant growth took place in deeper layers. No visible change and negligible growth occurred in litmus milk cultures incubated at 86° F. (30° C.) for one week.

The radio-resistant micrococcus grew over a wide temperature range. Growth occurred slowly at refrigeration temperatures 41° F. (5° C.). Most abundant growth was obtained at 77° F to 86° F. (25° C. to 30° C.). Growth was excellent at 98° F. (37° C.), but no growth occurred at 113° F. (45° C.). The radio-resistant bacteria isolated from ground pork and ground beef appeared to represent a single species closely related to *Micrococcus roseus* (ATCC 9815) and *Micrococcus rubens tetragenus* (ATCC 186). The latter two appeared similar to the newly isolated radio-resistant micrococcus in morphology, cultural characteristics, and many physiological properties including high catalase activity. They also demonstrated high resistance to gamma radiation, although theirs did not approach the extreme resistance of the new isolate.

DISCUSSION

Radiation resistance in bacteria usually has been associated with species capable of producing spores. However, the micrococcus isolated has shown resistance to radiation greater than any other bacteria previously encountered. The mechanism or protective agency responsible for such remarkable radiation resistance has not been established. Studies are in progress on composition, morphology, fundamental metabolism, and other aspects of the physiology of the organism in order to better understand the mechanism of resistance. One interesting feature in this connection is the high catalase activity characteristic of this species. Actually, catalase production appears greater than for any other bacterial species studied in this laboratory. The ATCC cultures 9815 and 186 also demonstrated higher than normal catalase production but less than the new radio-resistant isolate.

Another significant observation is the similarity in radio-resistance between isolates of the organism from unirradiated and irradiated meat. This indicates that the radio-resistance probably is a stable, inherent characteristic not acquired as a result of one or a few exposures to gamma radiation. Stability of the radio-resistant characteristic is of particular interest from the standpoint of its possible use as a test organism in food or other products subjected to irradiation.

Thus far irradiated and unirradiated strains have shown no significant differences in morphology, pigmentation, metabolism and nutritional requirements. The extremely high catalase production by the radio-resistant species may be of significance as a protective mechanism.

Temperature relationships of the radio-resistant organism are of considerable significance. Extensive growth at 41° F. (5° C.) in meat with consequent spoilage indicates that radiation plus subsequent refrigeration at temperatures above 32° F. (0° C.) may not provide adequate control of its activity in foods. Its facultative nature enables the organism to develop in hermetically sealed containers.

The explanation for the exceptionally high resistance of the organism on agar may lie partly in the nature of substrate irradiated and partly in age of cells undergoing irradiation. Cells streaked on agar slopes were older than those exposed in broth, and preliminary trials suggest a great variation in resistance to gamma radiation between young and old cells. Cells seem to demonstrate about the same order of resistance in meat and broth although age of cells again may complicate evaluation of the results. Age of the cells in naturally contaminated meat is difficult to assess.

Whether or not the radio-resistant micrococcus represents a new species must await further investigation. The fact that the two closely related organisms, *M. roseus* and *M. rubens tetragenus*, showed much lower resistance to radiation, suggests that they are fundamentally different. It is possible that investigations on physiology including metabolic pathways involved may clarify this aspect.

SUMMARY

A radio-resistant micrococcus resembling *Micrococcus roseus* and *Micrococcus rubens tetragenus* has been isolated from samples of ground beef and pork following gamma irradiation dosages of 2 to 3×10^6 rep. Pure cultures of the isolated organism have survived extreme exposures of 6×10^6 rep on agar slopes. This order of resistance was 6 to 8 times that of *Micrococcus pyogenes*, var. *aureus* and greater than that of any spore-forming bacteria tested in this laboratory. Strains of the organism isolated from naturally contaminated unirradiated meat demonstrated the same high order of radiation resistance.

Growth of the organism in irradiated meat or unirradiated meat was accompanied by CO_2 production and slight proteolysis in the closed can and marked proteolysis in the opened can. The organism occurred as gram positive tetrads, and produced a reddish brown pigment in laboratory cultures. Growth occurred slowly in refrigerated samples at 41° F. (5° C.), and not at all at 113° F. (45° C.).

Studies are under way to further characterize the radio-resistant micrococcus and establish its sources and habitat in nature. Investigations also are in progress on metabolism and other properties in an attempt to elucidate the mechanism of resistance.

Acknowledgment

The authors wish to acknowledge the assistance of Dr. P. R. Elliker, Bacteriology Department, for his suggestions during the course of these investigations and in the preparation of this manuscript, and Dr. H. W. Schultz, Food Technology Department, for his encouragement and cooperation. Appreciation is also expressed to Mr. William Sandine for his assistance in the laboratory.

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Chemical Ices for Shrimp Preservation[a]

E. A. Fieger, M. E. Bailey and A. F. Novak

Department of Agricultural Chemistry and Biochemistry, College of Chemistry and Physics and Louisiana Agricultural Experiment Station, Louisiana State University, Baton Rouge, Louisiana

(Manuscript received April 26, 1956)

Recent changes and developments in the shrimp industry have posed new problems in maintaining the quality of shrimp offered to the consumer—for example, the use of larger boats making more extended and farther trips to and from shrimp grounds; the introduction into commercial channels of new species more susceptible to deterioration in refrigerated storage; and the transportation of fresh shrimp to interior cities for processing. The sale of pre-packaged fresh shrimp which in many instances are not adequately refrigerated or protected invites the development of black spot or melanosis as well as other deteriorative changes. The shrimp industry, keenly aware of these problems, is searching for methods which will result in longer fresh storage life for shrimp and for the improvement in quality of the stored product.

If shrimp are stored in dry refrigeration, or if they are otherwise stored without constant contact with water as is achieved by ice storage, melanosis becomes a primary problem *(6)*. Frozen storage is undoubtedly the best method of preserving the quality of freshly caught shrimp, but black spot formation is still prevalent even in this type of storage.

Since freezing and refrigerating equipment in general are expensive to purchase and maintain, the usual commercial practice for storing fresh shrimp, particularly on the trawlers, is to place them in alternate layers between crushed ice. This being the case, it is very desirable to develop better methods of ice storage for this product. Investigations described in this paper and others to follow were undertaken with these objectives in mind, (a) to determine the effect of chemical ices on the ice storage life of fresh shrimp, (b) to study the effect of different chemical ices on the prevention of black spot in ice stored shrimp and (c) to determine the value of several chemical and physical tests as indicators of the relative quality of shrimp stored in various types of chemical and commercial ices.

Fieger and Friloux *(4)* have shown the maximum ice storage period for shrimp before the onset of spoilage is approximately 2 weeks. Since bacterial action is believed to be the primary cause of the rapid deterioration, incorporation of bacteriostatic agents into ice should, in theory, prolong this storage period. Several tests were therefore conducted using ices containing different concentrations of chlorotetracycline as well as other chemicals. The other chemicals usually were added to retard melanosis.

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MATERIALS AND METHODS

During the past 18 months, five storage tests were conducted using a total of 12 different chemical ices. These vary as to the chemical used or the concentration of the chemical. Most of these ices were prepared in the laboratory by freezing small increments of the solution in stainless steel pans in a plate freezer at —55° F. (—48° C.) Chlorotetracycline ices (CTC ices) were prepared by a commercial ice plant using Sea Kem No. 9 as the dispersing agent *(10)*.

The shrimp used in these experiments were purchased either directly from trawler owners or from shrimp processing plants. A historical summary of the shrimp and the ices used for their storage is presented in Table 1. In all cases, except Test No. 12,

TABLE 1

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10	*Penaeus setiferus*, size count 26-30, composite from several trawls, stored on trawler from 1 to several days.	(h) Commercial ice (i) CTC 5 p.p.m. plus sodium bisulfite 1500 p.p.m. ice (j) Sodium bisulfite ice 1500 p.p.m. Ices (i) and (j) were prepared by using Sea Kem No. 9 as dispersing agent	15 days
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12	*Penaeus setiferus*, size count 41-50, headed, washed and iced on trawler by members of the staff.	(o) Commercial ice (p) CTC ice 10 p.p.m. using Sea Kem No. 9 as dispersing agent (q) Salt ice 22,000 p.p.m. consisting of sodium chloride 20,000 p.p.m. plus calcium chloride 2000 p.p.m.	21 days

the shrimp were transported to the laboratory packed in commercial ice and upon arrival were thoroughly washed in ice and water and packed either in single layers in the various ices or were put in stainless steel baskets and then placed in the ices. Each basket contained 1¼ to 1½ pounds of shrimp, and when sampled, one basket was removed and its contents examined.

Chemical, physical and bacteriological tests for quality of shrimp stored in the various ices were conducted on samples taken either daily or on alternate days. These tests could be evaluated as a measure or index of quality and could also be used in evaluating the chemical ices in comparison with commercial ice in their ability to preserve fresh shrimp.

RESULTS AND DISCUSSION

As shown in Table 1, four different ices were compared as media for maintaining the quality of fresh shrimp in experiment No. 8. In general, the quality of the shrimp packed under the chemical ices used in this experiment was slightly superior to that of shrimp packed in commercial ice, but in no instance was the total storage time increased. Shrimp stored in the chemical ices were firmer and maintained their natural odors slightly longer than did the control shrimp.

The ascorbic acid-citric acid (8-92) ice and the bisulfite ice slightly decreased melanosis during the initial 5 days of storage. For longer storage periods, these ices were no more effective than commercial ice. The CTC ice had no effect on black spot formation in comparison with the control. Chemical ices did not reduce the number of bacteria on the shrimp. No difference in quality of shrimp stored in the various ices could be shown by the following objective tests, trimethylamine nitrogen, free sulfhydryl groups or pH.

Lack of effectiveness of CTC and bisulfite ices in Test No. 8 dictated a further test (Test No. 9) where higher concentrations of these substances were used. The concentration of the chemical in the former ice was increased to 5 p.p.m. and that of the latter ice to 1000 p.p.m.

Visual observations and chemical tests on these shrimp uniformly showed that the bisulfite ice was more effective in preserving shrimp than the CTC ice which was in turn more effective than the commercial ice. This is illustrated in Figures 1 and 2, in which pH and Nessler Nitrogen, respectively, are plotted against days of storage. Ordinarily during ice storage the pH of shrimp tissue progressively increases. On the basis of comparisons of organoleptic scores to pH, it is suggested that lower values are indicative of prime quality of shrimp, while higher values denote poor quality. In the Nessler test, low nitrogen values indicate shrimp of better quality, while high values or a rapid increase in nitrogen show onset of spoilage to be occurring. During the first 8 days of storage no significant differences were noted in the bacterial counts of the shrimp stored in the 3 types of ices (Figure 3). Both the bisulfite ice and the CTC ice retarded bacterial growth from the 8th through the 15th day of storage. The average reduction during this period was approximately 50%.

The bisulfite ice was definitely superior to the other two ices in preventing the formation of black spots and their severity (Figure 4). Although slightly fewer shrimp packed in CTC ice developed melanosis in comparison with those stored in commercial ice, the former

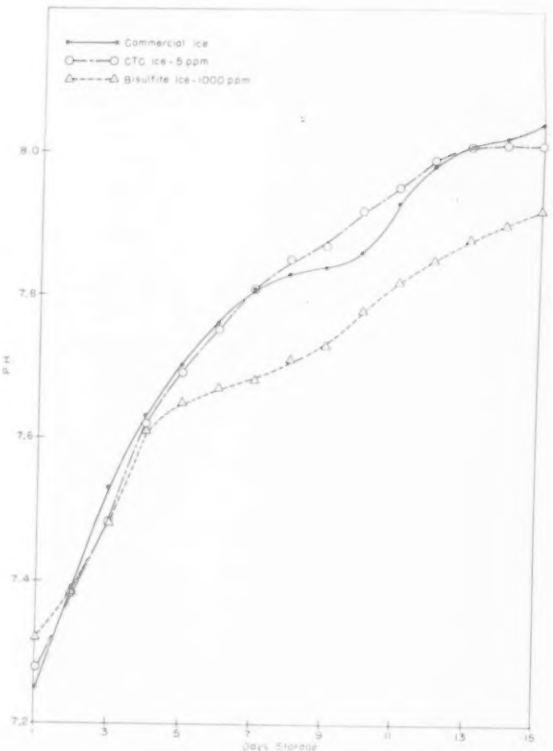

Figure 1. Comparative effects of commercial, CTC and bisulfite ices upon pH of shrimp during storage.

had a greater number of severely developed black spots.

Ices containing 5 p.p.m. CTC or 1000 p.p.m. sodium bisulfite delayed the onset of spoilage by two days and in general resulted in shrimp which had less off-odors, were firmer and less slimy than the controls.

A major problem confronting the fresh shrimp industry is the prevention of melanosis. As indicated above both CTC ice and bisulfite ice extended the storage life two days, but the former was not effective in preventing black spot particularly those rated severe. Since both CTC and bisulfite reduce bacterial loads of shrimp stored in such ices and the latter inhibits melanosis it was decided to investigate the use of a mixture of the two in ice (Test No. 10).

The shrimp stored in the bisulfite-CTC ice definitely had less off-odors and better general appearance after the 10th day of storage than did those stored in the other ices. Shrimp stored in the sodium bisulfite ice had a slightly better general appearance and had less off-odors than the control during the last 6 days of storage.

Daily observations were made on the development of melanin spots, and these were classified as to degree of intensity as follows: (a) barely detectable; (b) intermediate in intensity; and (c) severe. The sodium bisulfite ice retarded all degrees of black spot and total black spot development over the 15 days' storage; the bisulfite-CTC ice retarded black spot formation only during the first 7 days of storage. After this initial period, the rate of increase in the number of black spotted shrimp was greater than for the control (Figure

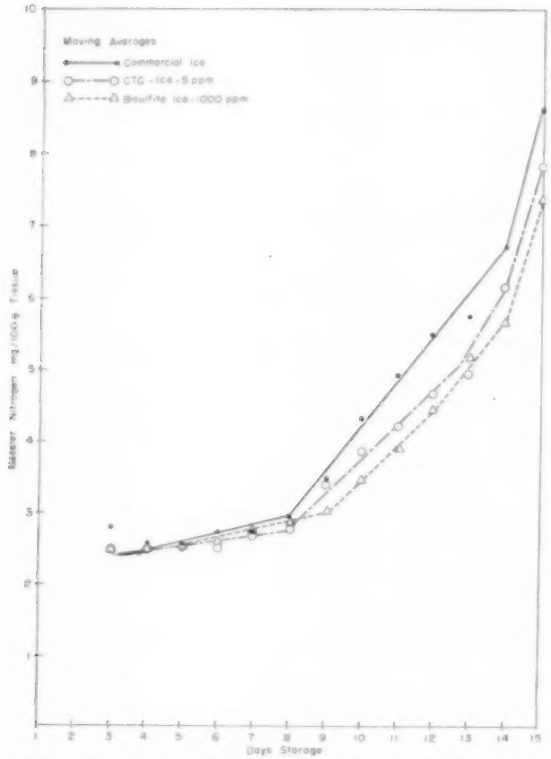

Figure 2. Comparative effects of commercial, CTC and bisulfite ices on Nessler Nitrogen content of shrimp during storage.

5). Apparently, melanosis is not decreased by CTC. Sodium bisulfite not only prevents melanosis but also bleaches previously formed black spots when used in concentrations at, or above, 1000 p.p.m. This occurs during the latter part of the storage period when melanosis is ordinarily most severe. When bisulfite is used in combination with CTC it is not as effective in counteracting black spot development as bisulfite alone.

There were no appreciable differences in the bacterial plate counts of shrimp stored in the various ices until the 10th day of storage. After this time the bacterial counts for the control and for the shrimp stored in bisulfite ice increased steadily through the remainder of the storage period. The bacterial plate counts for samples from the bisulfite-CTC ice increased slowly after the 11th day of storage.

No differences in quality were indicated by the objective tests, lactic acid content or soluble orthophosphate, while the glycogen content indicated that the bisulfite ice stored shrimp were of better quality from the 7th to the 14th day of storage than shrimp stored in the other two ices. The objective physical test, hydration of shrimp tissue, indicated that shrimp stored in commercial ice imbibed water more rapidly than those stored in the other two ices. Previous work shows a correlation between water uptake and number of free sulfhydryl groups in shrimp proteins, indicating a faster rate of denaturation of the proteins of the shrimp stored in commercial ice *(2)*.

Results obtained in Test No. 10 are similar to those obtained in Test No. 9 in that, at most, 2 to 3 days of added storage life are obtained through the use of these chemical ices. At the concentration used, sodium bisulfite in combination with CTC was ineffective in adequately preventing black spot formation during the latter part of the storage period. When conditions favor development of melanotic shrimp, sodium bisulfite ices at 1000 to 1500 p.p.m. can be used to effectively prevent black spot formation and improve the quality of stored shrimp.

In Test No. 11 (Table 1) the value of 3 chemical ices were compared. None of the shrimp stored in these chemical ices were sufficiently superior to warrant further study of these ices. Only the tannic acid ice inhibited melanosis, but these shrimp had a greenish color from the first day of storage. This off-color precludes further consideration of this material as a preservative for shrimp.

In the final quality test, Test No. 12, a salt ice was used as well as a CTC ice and commercial ice. Recently it was reported *(7, 8, 9)* that sea water ice was effective in prolonging the storage life of marine fish in comparison with similar fish stored in commercial ice. It was decided therefore to prepare a salt ice of such concentration that it would melt at approximately 30° F. (—1° C.).

The inability of CTC ices to markedly reduce bacterial counts and prolong storage life, which is opposite to the results reported by Gillespie, Boyd, Bissett and

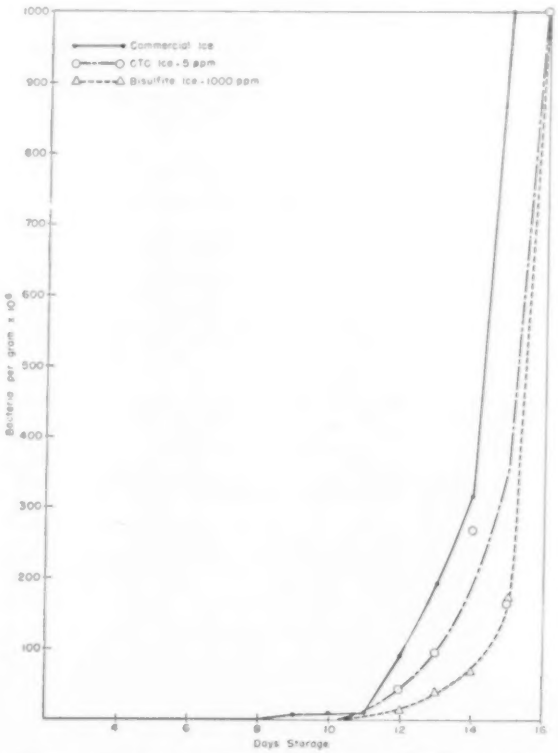

Figure 3. Effect of commercial, CTC and bisulfite ices on the bacterial counts of shrimp during storage.

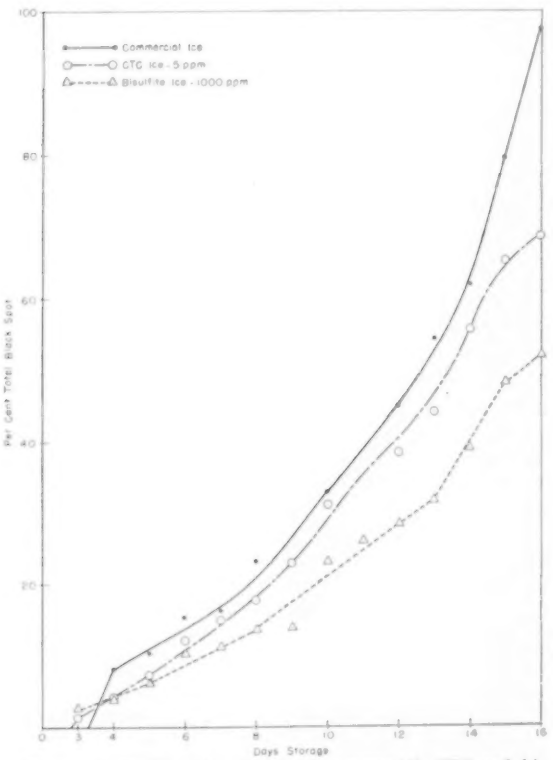

Figure 4. Comparative effects of commercial, CTC and bisulfite ices on melanosis of shrimp during storage.

Tarr *(5)* and by Farber *(3)* for fish, but confirms the latter's results with shrimp, suggested that the time interval between catching and treating with CTC ices was a factor. Therefore, two members of the staff were aboard a trawler to handle the catch from the time the net was emptied on the deck. The shrimp were separated from the trash fish and headed into a box containing ice. Extra ice was added as required. After completing the heading operation the shrimp were washed in the box with sea water. They received no further washing. One-third of the shrimp were placed in a solution containing 55 p.p.m. CTC. They remained in this solution, with occasional stirring, for 15 minutes and were then removed and packed in "snow" ice containing 10 p.p.m. CTC with Sea Kem No. 9 and calcium acetate as dispersing agents.

Another third of the shrimp were placed in a solution containing 20,000 p.p.m. sodium chloride and 2,000 p.p.m. calcium chloride. They remained in this solution, with occasional stirring, for 15 minutes and were then removed and packed in salt ice.

The remaining one-third of the shrimp were packed in commercial ice. All were transported to the laboratory, where they were repacked in the corresponding fresh ices for storage and sampling.

It was concluded from general observation that there were no differences in odor, firmness or sliminess between samples stored in the three types of ice during the first 15 days of storage. Shrimp stored in the CTC ice longer than 15 days had the least odor but after 21 days had a strong fishy odor. Shrimp stored in the commercial ice and the salt ice had respectively a putrid-sour odor and a slight putrid odor. Also, at the termination of the test on the 21st day, samples stored in the CTC ice had the smallest number of shrimp showing the feverish red color of spoiled shrimp, shrimp stored in salt ice were firmest and had the least amount of slime. CTC ice-stored shrimp were intermediate and the controls were the softest and the most slimy.

Neither the salt ice nor the CTC ice were as effective as commercial ice in delaying the development or severity of black spot (Figure 6). The salt ice melted at 29.7° F. (—1.3° C.) and it was observed that some of the shrimp were partially frozen. This may explain the high incidence of black spot on shrimp stored in this type of ice. The pH of the ices were as follows: commercial ice 9.08; salt ice 8.93 and CTC ice 9.08, which may have contributed to black spot development by maintaining a favorable medium for the enzyme which catalyzes the formation of melanin.

The objective tests for quality, amount of soluble orthophosphate and trimethylamine nitrogen, indicated that salt ice and CTC ice were effective in delaying deterioration in quality. The trimethylamine nitrogen values showed that beginning spoilage of shrimp occurred after 16 days storage in commercial ice, after 18 days in salt ice and 20 days in CTC ice.

The results of the bacteriological phase of the investigation are presented in Figure 7. Both the salt ice and the CTC ice were of equal value in reducing bacterial

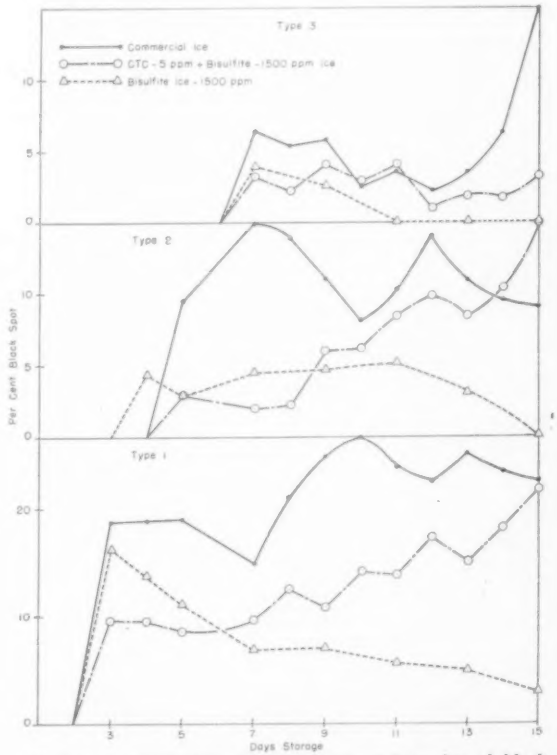

Figure 5. Comparison of the degree of intensity of black spots in ice stored shrimp.

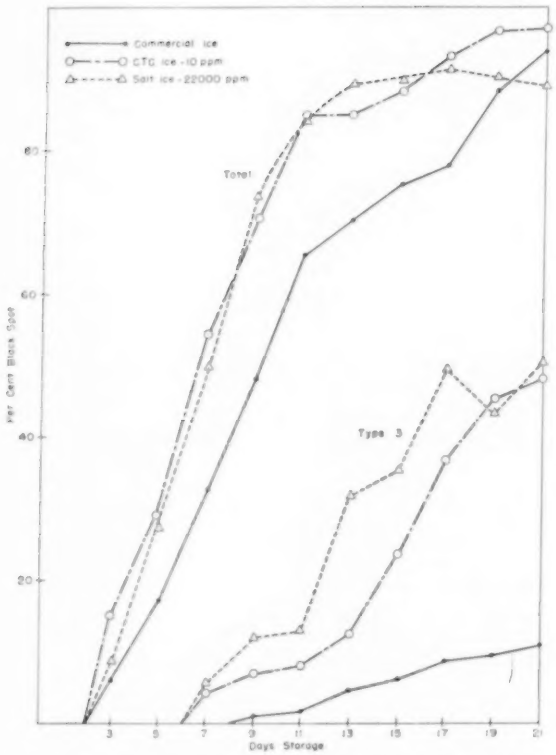

Figure 6. Development of severe and total black spots on shrimp stored in various types of ices.

development. Analysis of shrimp for CTC after 21 days CTC ice storage gave the following results: flesh 1.2 γ per g., shells 7.0 γ per g., and ground headless shrimp 4.0 γ per g. It would appear that at the termination of the experiment ample CTC was present. Counts obtained during the latter part of the storage period for shrimp stored in the three types of ice are much lower than have been obtained in previous work and can be ascribed to the rapid handling and thorough washing of the shrimp on board the trawler.

Ordinarily, shrimp stored in commercial ice retain their top quality for the first 6 to 8 days, after which time they acquire a flat taste but are still edible. At the end of 14 to 16 days of ice storage, the shrimp develop strong off-odors and are considered undesirable for human consumption. Most work in the preservation of shrimp and other fishery products is ordinarily directed toward extending the total storage life in ice. In the work reported here some of the chemical ices extended storage life 2 to 3 days, and prolonged the period of top-quality as much as 3 days. This was especially true of such ices as sodium bisulfite (1000 and 1500 p.p.m.); a mixture of sodium bisulfite (1500 p.p.m.) and CTC (5 p.p.m.); CTC (10 p.p.m.) and salt ice (sodium chloride 20,000 p.p.m. plus calcium chloride 2000 p.p.m.). The other ices used were ineffective in appreciably extending storage life or showing marked improvement in quality in comparison to the controls.

The CTC ices were not as effective in reducing the bacterial load on shrimp as has been reported for fish *(5)*. This failure may be caused by the high pH of these ices and the alkaline character of stored shrimp; under these conditions CTC is not stable *(5)*. Also, as pointed out above, CTC ices were of no value in preventing melanosis.

Any chemical additive to be an effective agent for preserving shrimp should inhibit melanosis. Of the materials used, sodium bisulfite at concentrations of 1000 or 1500 p.p.m. retards melanosis very well during the first 15 days of storage. Where black spot is a serious problem the use of such ices is recommended.

RESIDUAL SULFITE IN COOKED SHRIMP WHICH HAD BEEN STORED IN 1500 P.P.M. SODIUM BISULFITE

The residual sulfite was determined in shrimp after processing in a commercial plant which produces frozen cooked shrimp. These shrimp had been stored for 10 days in the sulfite ice. The average of 5 samples, as determined by the revised Monier-Williams method *(1)*, was 5.0 mg. of sulfite ($SO_3^=$) per 100 grams of shrimp tissue. In a second experiment shrimp stored for varying periods of time in 1500 p.p.m. sodium bisulfite ice were analyzed before and after cooking by a method similar to that used by housewives. The data are presented in Figure 8.

Organoleptic tests were also conducted on shrimp packed in 1500 p.p.m. sodium bisulfite ice for 8 days and then stored for varying lengths of time at —40° F.

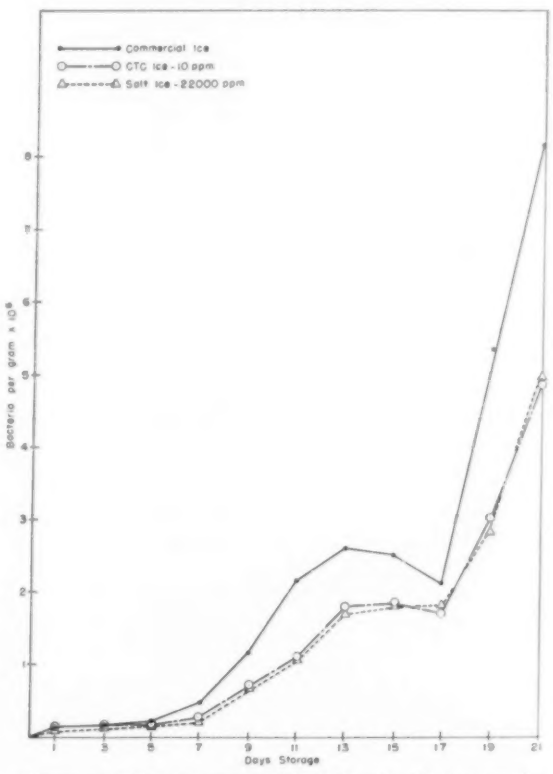

Figure 7. Effect of commercial, CTC and salt ices on the bacterial counts of shrimp during storage.

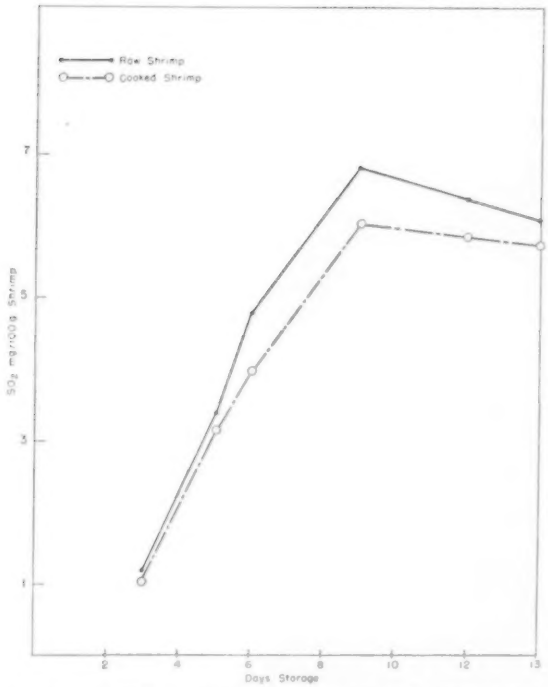

Figure 8. Sulfite content (as SO_2) of raw and cooked shrimp stored in 1500 p.p.m. sodium bisulfite ice for varying lengths of time.

(—40° C.). Samples were removed monthly and compared with similarly frozen samples which had been stored in commercial ice. The sulfite treated shrimp were found devoid of any undesirable flavors during four months of storage. Shrimp tissue, not protected by the shell, in contact with pieces of ice containing high concentrations of sulfite became opaque white. Such areas, upon cooking, became brown in color and are tougher than surrounding unaffected areas. Individuals sensitive to sulfite readily detect a sulfite flavor upon tasting such areas.

Should the shrimp industry use sulfite ice to control black spot and delay spoilage it will be necessary to prepare ice of relatively uniform concentration of the added chemical. Concentration of sulfite in the core of the block of ice will bring about the condition described above in spite of crushing and thoroughly mixing the ice.

SUMMARY AND CONCLUSIONS

The object of this study was to determine the value of chemical ices in delaying loss of quality, onset of spoilage and prevention of melanosis in ice-stored shrimp. Simultaneously a study was made to determine the value of several chemical and physical tests as indicators of the relative quality of shrimp stored in these ices and in commercial ice.

The following ices were no more effective in preserving shrimp than commercial ice: CTC ice 1 p.p.m.; sodium bisulfite ice 100 p.p.m.; acid ice pH 5.0; Fran-Kem ice 500 p.p.m. and tannic acid ice 500 p.p.m.

While the CTC ice, 10 p.p.m., delayed deterioration and onset of spoilage for two to four days it was of no value in preventing melanosis. Inclusion of sodium bisulfite in CTC ice to control black spot was not as effective as bisulfite ice.

Sodium bisulfite ices at 1000 or 1500 p.p.m. delayed deterioration and spoilage for approximately two days and were very effective in preventing melanosis, particularly during the latter part of the storage period when black spot is most severe. When melanosis becomes a problem sodium bisulfite ices of the above concentrations can be used to effectively control black spot and to improve the quality of stored shrimp.

Ice containing 20,000 p.p.m. sodium chloride and 2,000 p.p.m. calcium chloride extends the ice storage life of shrimp by 2 days but is of no value in controlling black spot.

Of the objective tests for quality which were studied the determination of pH, amount of Nessler Nitrogen and degree of hydration of shrimp tissue can be used to distinguish differences in quality of shrimp stored in various types of ices. The trimethylamine nitrogen content and total bacterial plate counts can be used to indicate onset of spoilage.

Acknowledgments

We are indebted to Robert Frost, Mary Hanford, James Oertel and Raymond Wille and the Lederle Laboratories Division, American Cyanamid Company for technical assistance. The chlorotetracycline was generously donated by the Lederle Laboratories Division of the American Cyanamid Company.

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Measurement and Control of the More Difficult Process Variables[a]

Wm. J. Scarlett
Brown Instruments Division, Minneapolis-Honeywell Regulator Co., Philadelphia, Pennsylvania

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A GREAT AMERICAN, OLIVER WENDELL HOLMES, once observed: "I find the great thing in this world is not so much where we stand, as in what direction we are moving." We are moving today, at an accelerating pace, in a direction which involves considerable technological development. In the food processing industry the pressure is constantly felt for improved quality, better nutrition, greater value, and increased acceptability. The ever-increasing competition for the consumer dollar requires constant examination and evaluation of processes, methods, and products.

Thought and attention are being given today to the adoption of more effective means of maintaining the process variables within closer tolerances during manufacture. This involves the more direct measurement and control of those properties which constitute the essential elements of desirable quality. Many strides have been made in the process industries to transfer control functions previously carried out in the laboratory to in-stream measurement and control of those more difficult variables.

Industrial control has come a long way toward solving those problems which have stood in the way of continuous processing. Originally automatic control was pretty much limited to the simple variables such as temperature, pressure, flow, and level. Experience and tradition established the effects of these on final product quality, and operating safe limits were determined empirically. With the trend toward continuous processing and its advantages of more efficient operation, more economical use of space, facilities, equipment and manpower, it became increasingly important to measure and control directly the important end-point qualities of the product. This is in contrast to the more common procedure of operating the process, sampling product, and evaluating results by laboratory testing and quality control. The development of new technics and methods of control have the added advantage of measuring and controlling *what is being done* rather than subsequently evaluating *what has been done*. Thus we have learned, at least in some instances, to control directly the significant variable rather than to depend on the empirical method of evaluating the effect of secondary variables like temperature and pressure and the attendant time factors.

The purpose of the present paper is to point out some of the comparatively recent developments in the process industries wherein some of the more difficult process variables are being measured and controlled. These examples—only a few of the many which might be cited—present a challenge to the food technologist, the process engineer, and the control engineer to adapt them to the specific problems of the industry.

We have become familiar with the means of measuring (and that is synonymous with controlling) some variables which only a few years ago required more or less laborious laboratory methods. Some of these means, extensively used today, are pH electrodes, conductivity cells, and strain gauges.

Each of these depends on and operates by the principle that a sensing element gauges the significant variable and develops a minute electrical signal proportional to variations in that variable. Through electronic equipment this signal is amplified many times and through proper mechanical motion sets up indicating, and/or recording, and/or controlling action to alter the process conditions if they are not within allowable limits or to hold them where they belong if they are within limits. Commercial electronic equipment available now will accept and operate on such minute electrical impulses as voltages as little as 10^{-6} volts and currents as minute as 10^{-15} amperes.

Low-level nuclear radiation. One of these recent control developments involves the use of low-level nuclear radiation. A constant emission source directs radioactive energy toward a cell which directly converts this energy into electrical energy. Any substance placed between source and cell affects the amount of energy striking the cell. Electrical energy is thereby produced which is inversely proportional to the substance. To date this method of measurement has been used as a primary measuring means for:

- Specific gravity
- Liquid level
- Solids level
- Liquid-Liquid Interface location
- Liquid-Solid Interface location
- Concentration of Alpha, Beta, Gamma or Neutron Radiation
- Variation of particle Size of Granular Materials
- Density
- Percent Solids
- Thickness

Its possible uses are legion—limited only by creative imagination and necessary safety measures. The level of radiation is, of course, very low—so low, in fact, that no radioactivity is imparted to the product; yet the signals can be amplified sufficiently to give very close control to the significant variable. A typical cell generates 2×10^{-12} amperes when exposed to a radiation field of one milli-roentgen per hour from radium. When this cell is used with a standard electrometer on its most sensitive range, 10% of full scale will correspond to 0.005 mr per hour.

Radio active sources of Radium, Cesium 137, Cobalt 60 and other isotopes have been used. These are supplied in source holders designed for the service as a point source where the necessary amount of material is concentrated into as small a volume as possible. Also available are strip sources where the material is dis-

[a] Presented at the Sixteenth Annual Meeting of the Institute of Food Technologists, St. Louis, Missouri, June 12, 1956.

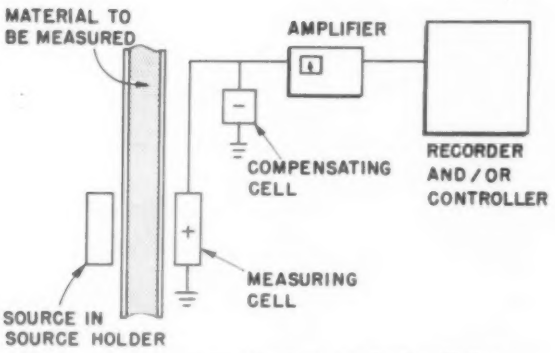

Figure 1. Density gauging with low level radiation.

tributed evenly over the length of a source holder. Sources applied to various operations are selected for the particular requirements involved.

Radioactive gauging is not new *(5)*. It was first investigated in 1900 by P. Villard. His initial experiments involved passing rays from a radium source through multiple layers of photographic plates. Out of this work came the discovery that radio activity included at least 3 types of emission. These were named alpha, beta, and gamma. It was learned that the penetrating power of alpha rays was limited to a fraction of a millimeter of aluminum. Beta rays penetrate several mm. of aluminum and the more powerful gamma rays will penetrate several centimeters of the same material. It remained for the availability of radioactive isotopes to place this means of measurement at the disposal of industry.

To measure density, for example *(4)*, of a substance with a variation in specific gravity of 1.0 to 1.2 it would be reasonable to select a cell which would generate a current of ten units for gravity 1.0. This cell could be selected so that it would generate 8 units for gravity 1.2. The compensating cell is then adjusted to generate a current of 10 units which we term residual current. Adding algebraically the outputs of the measuring cell and the compensating cell would produce zero output to the amplifier. As density increases to 1.2 we have a negative net increase of 2 units which we term Delta I. The amplifier sensitivity is adjusted so that Delta I will produce full scale of deflection. Thus the indicator on the amplifier shows full range over a variation in gravity of 0.2 units. It is possible to select cells to give 10 and 100 times this sensitivity so that possibilities of extremely close measurement are available. Signals from the amplifier fed to an electronic potentiometer are again amplified to provide the control and/or indicating and/or recording functions.

The flow colorimeter. A comparatively recent development in the field of control has found its widest acceptance in the food industry *(1)*. It is a continuous flow colorimeter or photometer. This instrument has been used to indicate, record, or control color of flowing liquids. It has been used for the color grading of water, beer and fruit juices. It is quite widely used in turbidity control of beer and refined sugar syrup.

The flow assembly can be mounted next to the plant stream and a portion of the stream diverted through the flow chamber. The amplifier and recorder may be mounted in the process control room as much as 200 feet away. By making the by-pass sample line as short as possible it is obvious that quick response to variations in color intensity of the process stream will obtain. Locating amplifier and recorder in the control room centralizes and simplifies observation and maintenance of the instrument by operating personnel.

In the illustration are shown two methods of setting up the flow colorimeter. Position A is used for detecting changes in color intensity and turbidity; right angle viewing (position B) is used for nephelometric measurements. The instrument can be readily adapted to a wide variety of process needs and operating conditions by selecting appropriate flow chamber material, filter, light path length and photo-tube.

Color has long been recognized as a prime factor in food quality control. Many years of laboratory work have involved spectrophotometric methods and the International Commission on Illumination nomenclature. Since World War II there has become available a tristimulus meter for color measurement *(6)*. It uses three filters approximating the three basic color functions of the I. C. I. system. This gives readings which very closely similate the color-perceptive response of a human observer.

From objective evaluation of color by instruments such as these and correlating instrument results with consumer reaction, it has been found that in many cases a single or at most two of the color dimensions provide the dominant factors in human reaction. For example, the anthocyanin pigment of strawberries can be measured with a single color filter yet if this falls within a certain established range, it has been shown that consumer acceptance is assured.

Much remains for the food technologist to explore in compiling the necessary fundamental data for many products. The foregoing lends great encouragement to those who would simplify the problems of measurement and control of those qualities that govern the human acceptance of food products.

The previously described instrument is designed, of course, for liquid products or products in the liquid state. Other types are also available for these measurements in products in the solid state.

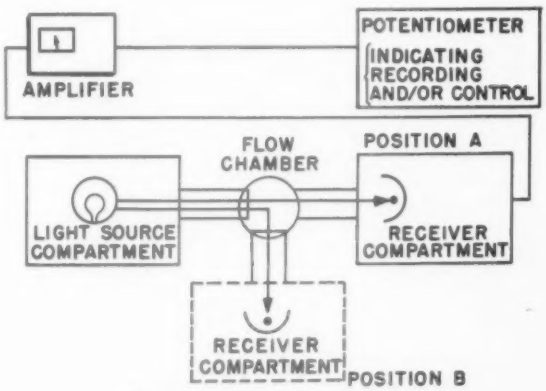

Figure 2. Flow colorimeter.

We could go on with other examples in the field of spectroscopy, spectrophotometry and other optical instruments, development of which has attained high degrees of sensitivity, accuracy and reliability.

Continuous refractometer. One other optical instrument which has been developed for and applied to in-stream process control is a continuous refractometer. Up to the present, use of this instrument has been limited to reasonably clear fluids. Its principles are such that suspended matter upsets the optical system, and it is therefore not adaptable to tomato or citrus products in its present form. It has found application in the chemical field and is especially suitable for such food industry applications as margarine, shortening and other hydrogenated oils.

Two variations of these are of particular interest. One variation, the Hollow Prism Refractometer, is shown in block diagram herewith.

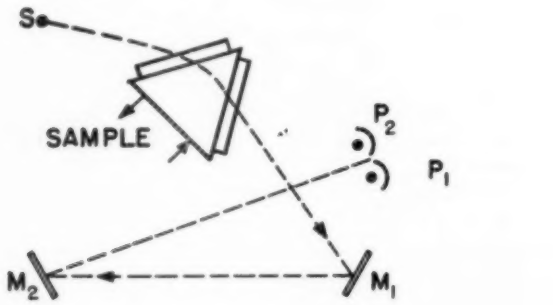

Figure 3. Hollow prism refractometer.

Light from source S is filtered (5461Å), collimated and passed through a hollow prism-shaped cell in which the sample is flowing. The emergent refracted beam is folded back by mirrors M_1 and M_2 to increase the beam length and focused on phototubes P_1 and P_2. Deviation of the beam from the prism as related to entrance beam is a measure of the index of refraction at the liquid-glass interface. By use of mirrors M_1 and M_2, lengthening the light beam results in increased sensitivity.

Phototubes P_1 and P_2 are of the duplex type and are mounted on a carriage free to move horizontally at right angles to the emergent light beam. Motion of the carriage and assembly is controlled by a balancing servo-motor actuated by signals from the photo-tubes. Connected to the movable carriage is a resistance slide-wire, the voltage from which is fed to a strip chart potentiometer. With an exit ray path length of 120 inches, the range of this instrument is 0.161 and accuracy is ± 0.0001 refractive index units. By rotating the prism cell and repositioning mirrors M_1 and M_2 it is possible to cover a refractive index range from 1.3 to 1.7.

Several years ago some independent work in the research laboratories at Phillips Petroleum Co., Bartlesville, Oklahoma, resulted in a highly successful differential refractometer *(7)*. This work was carried on by Messrs. Miller, Crawford and Simmons. Several in-stream units were ultimately built by this group and were applied to process control.

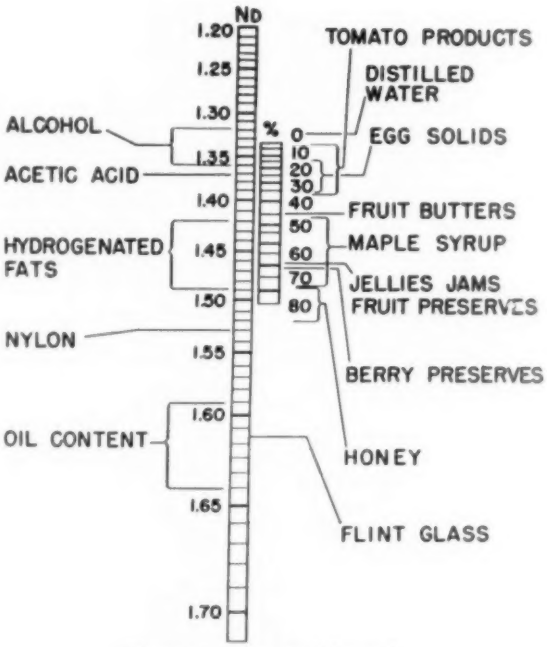

Figure 4. Refractive index scale.
(Courtesy Bausch & Lomb)

Collimated light from source S passes through adjacent prism cells, one containing a reference sample and the other the flowing test sample. The exit ray is folded back as is usual in this type of instrument, by mirrors M_1 and M_2. The emergent beam is focused on barrier-layer photocells P_1 and P_2. In this case, deviation of the transmitted beam as it crosses the interface between the cells is a measure of the difference in refractive index between the sample and the reference fluid. Zero position for the instrument is readily established by filling both chambers with reference fluid. For operation on a process stream, composition of the reference mixture should, of course, represent the characteristics of the specification product.

Sensitivity of the instrument is a function of the path length of the exit beam prior to its reaching the photocells. Foldback mirrors are used here also to permit maximum length of beam and therefore high sensitivity within a reasonably small instrument housing, and, of course, to mechanically position the focused emergent beam. Signals from P_1 and P_2 in this instance operate a balancing servo-motor to which a cam arm arrangement causes M_1 and M_2 to rotate to the balance position. Geared to the motor shaft is an indicator needle showing refractive index. Also geared to this motor shaft is a helipot for furnishing signals to a remotely located electronic potentiometer for indicating, controlling and/or recording.

Temperature compensation, always necessary in refractive index determinations is accomplished by maintaining an equilibrium temperature between reference

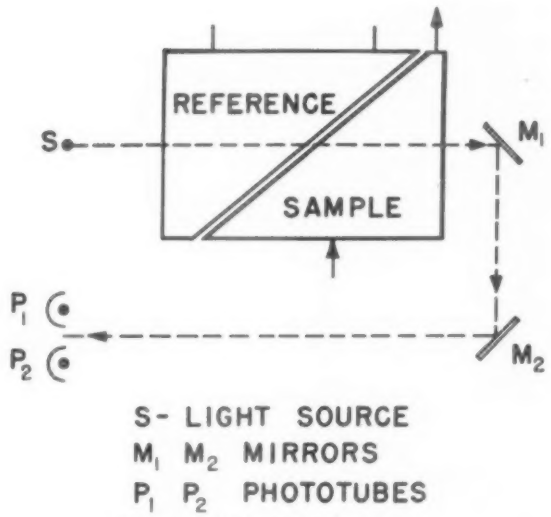

Figure 5. Differential refractometer.

and flowing samples. Pressure compensation is achieved in a similar manner. Errors caused by formation of films on cell windows are minimized in this type of refractometer. Because films, if any, tend to build up equally in both chambers. Span range for a given reference liquid in this apparatus is 0.01 refractive index units and accuracy ± 0.0001 units. For oil refinery work the units built at Bartlesville were made capable of pressure operation up to 150 p.s.i.g. and they were rendered explosion proof.

ULTRA-SONIC MEASUREMENTS

Viscosity, tenderness, texture are the variables which are likely to be accurately gauged by the ultrasonic system. It has been successfully applied to the measurement and control of the viscosity of a considerable number of products which are both Newtonian and Non-Newtonian in character. Indications are that by proper adaptation and technics there is good possibility that it will become a means of measuring those elusive variables so important and yet so difficult that they almost defy definition, tenderness and texture.

Viscosity. First let us look at viscosity since the ultra-sonic system has been applied most frequently to the measurement and control of this variable. Viscosity, of course, is a measure of resistance to flow. It can be expressed mathematically *(2)* as follows:

$$F = A \frac{dv}{dy}$$

in which

F = Force in Dynes
η = Absolute Viscosity, Poise
A = Surface area sq. cm.
V = Velocity Cm./sec.
Y = Plate Separation, Cm.
$\frac{dV}{dY}$ = Rate of shear, Sec.$^{-1}$

$$\text{For Newtonian liquids—Viscosity} = \frac{\text{Shear Stress}}{\text{Rate of Shear}}$$

which is a constant. For Non-Newtonian liquids the formula holds but becomes more complicated because the value is not constant.

In Figure 6 Absolute Viscosity is defined as shear stress per unit area (F/A) divided by rate of shear (dV/dY).

A graphic presentation of the characteristics of Newtonian and Non-Newtonian fluids may show an approach to the problems involved in their measurement.

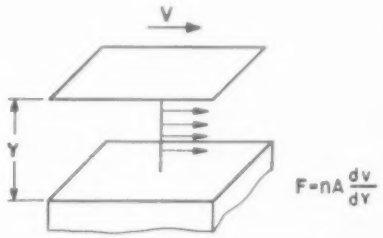

Figure 6. Theory of viscosity.

In Figure 7 are shown curves of viscosity vs. flow rate for various types of liquids. In Newtonian fluids, viscosity remains constant as flow rate increases. In thixotropic fluids, viscosity decreases and in dilatant fluids the viscosity increases as the flow rate increases.

This clearly shows that a Newtonian fluid is one in which F is proportional to the rate of shear or more simply viscosity remains constant as flow rate increases. A fluid is Non-Newtonian when its viscosity changes as a function of flow rate.

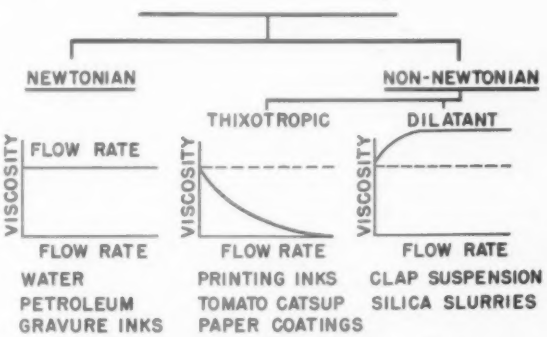

Figure 7. Newtonian and Non-Newtonian liquids.

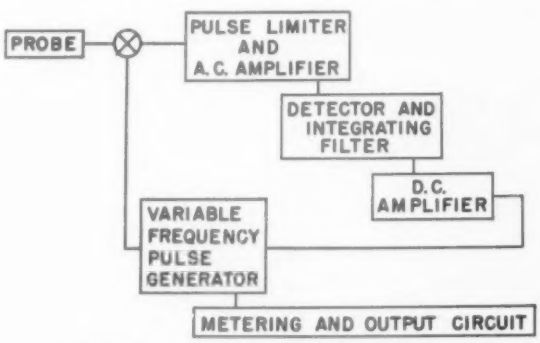

Figure 8. Block diagram ultra-sonic system.

The ultra-sonic system comprises a probe which is set in motion by electrical pulses from a pulse generator, a pulse limit device and amplifier, detecting and integrating filter, a d.c. amplifier and a variable output device to provide a full scale output of the order of 0-50 millivolts which may be delivered to a standard electronic potentiometer.

The probe which is the transducer (T/C-R/T) acts alternately as transmitter and receiver for ultra-sonic energy. The sensing element is a 4″ strip of magnetostrictive alloy. The computer induces short pulses of current in a coil located within the probe barrel. This is shown in:

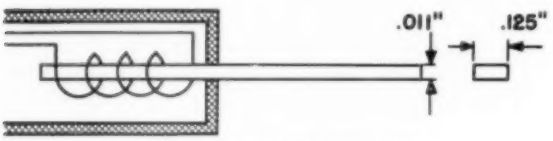

Figure 9. Ultra-sonic transducer.

Current pulses cause the blade to vibrate at its natural frequency of 28 kilocycles. Motion of the blade tip is approximately ½ micron and shearing action is in the longitudinal plane rather than at right angles to blade length.

Ultra-sonic longitudinal vibrations are pulsed periodically. As amplitude decays approximately 1/500, the pulse is repeated. Time for decay and thus rate of pulsing are a function of viscosity.

The full scale accuracy of this system is ± 2% and reproducibility is better than 1%.

Since viscosity varies with temperature, it is important that temperature of the sample fluid be held within close limits or that a means of automatic temperature compensation be included in the system.

The problems of viscosity measurement are quite complex. Newtonian fluids present a less formidable approach and it is natural that these have been quite completely solved in many instances. Non-Newtonian fluids present an entirely different set of problems and their solution is considerably more complex.

"A HIGH DEGREE OF REPRODUCIBILITY"

The significant observation with all of these sophisticated instruments is that they develop a high degree of reproducibility. This is important and makes these devices most attractive since one is not usually concerned with absolute values. Once the parameters for a given product are set up and the result is a product having the desirable qualities, the conditions responsible for the end product results can be reproduced accurately and within close limits time after time.

Work in the food technology laboratory to establish the fundamental bases for the use of the aforementioned instruments to further improve process control and to pave the way for more continuous processing are indicated.

For example the use of the ultra-sonic viscosity device has been extended to such complex studies as that of blood coagulation *(3, 8)*, printing inks and paper coatings all of which are Non-Newtonian and of a thixotropic nature. Applications have also been made to the dilatant group of Non-Newtonian fluids such as silica slurries and clay suspensions in process control.

We have brought to your attention various commercially used process control equipment. In the low level radiation field we have many examples of measurement and control of mass, thickness, specific gravity and level. There is every reason to believe that fundamental work with specific products may lead to the determination of its use for such important variables as composition and texture.

In the determination and control of color we have reviewed the relatively simple photometer which is currently being used quite widely as a color comparator for refined sugar liquor and has been applied to brewing operations for both color and nephelometric control. Its uses in the color field either for liquids or solids carries implications of a great many uses.

A continuous control refractometer may have rather limited scope in its present form. The fact that it is not applicable to measurements of fluids including suspended solids limits its application in the food industry. Work is going forward on this phase of the problem however. It is expected that this limitation will be removed shortly. In the meantime there are many cases in which the continuous measurement and control of refractive index of clear fluids will pave the way to more efficient process operations.

While we have discussed at some length the theory of viscosity and an ultra-sonic means of measurement, the instrument need not be limited to this purpose. There is every reason to believe that this method will lead to a means of determining the all-important qualities of texture and tenderness in certain products, at least.

Here are a number of tools which are not idly theoretical in their use. Each has proven to be of great value and each has been used successfully in the process industries. These and others of like nature but dealing with other difficult variables are available and are today in use.

Thus we have the tools, the opportunity and the challenge to apply these tools to the problems of our industry. By such means is progress made toward better, more efficient, and more effective food processing operations.

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Recent Developments in Fruit and Vegetable Powder Technology[a]

M. J. Copley, V. F. Kaufman, and C. L. Rasmussen
Western Utilization Research Branch, Agricultural Research Service, United States Department of Agriculture, Albany 10, California

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PRODUCTION OF A FOOD IN POWDER FORM approaches the ultimate in concentration and offers convenience, versatility, and storage stability without refrigeration—all factors of importance in our various food-supply problems. Many foods are processed in powder form. Onions, garlic, and other seasoning powders are ground from dehydrated pieces. Milk powder is processed in a number of ways. Potato flour is ground from drum-dried sheets of potato solids. Cereal flours and instant coffee are other examples of food in powder form.

Juice powders have been conspicuous by their absence but not because of a lack of effort in juice powder development; a bibliography on research to make juice powders would contain many entries.

A basic difficulty with juices arises from the fact that they contain a large proportion of hygroscopic sugars. In addition to the problem of caking resulting from ready moisture take-up, early types of fruit juice powders had other shortcomings. Generally the powders did not retain adequate fruit flavors, which were either lost or oxidized, and often the powders were very dense, making reconstitution difficult if not impossible. In an effort to overcome the difficulties, large amounts of sucrose and low-conversion corn sirup solids have been added to fruit juices before drying. The products proved moderately successful.

The production of full-flavored, 100% food powders is, of course, the objective. A powder containing a major proportion of additives is a long way from this goal. Events of the past decade, however, have served to change this picture and now, for the first time, 100% orange and grapefruit juice powders are being produced commercially. Other fruit and vegetable juice powders are under consideration. The inherent difficulties mentioned above have been largely overcome by six recent advances, which are discussed separately in the following sections.

Research in the Western Utilization Research Branch during 1951-53 resulted in the successful production of a 100% orange juice powder, described at the IFT meeting in June, 1953 *(26)*, and in *Food Engineering* in March, 1953 *(27)*. These papers discussed how use of these six advances resulted in the production of a 100% orange powder. None of these developments was entirely new. The contribution of the Western Branch consisted of improving them and using them all in a single process.

RAW MATERIAL REQUIREMENTS

The quality of the raw material used places an upper limit on the quality of product. It is axiomatic that the product will be no better than the juice from which it is produced. In addition, there are certain specific requirements that need to be considered to produce a satisfactory powder by puff drying. They are as follows:

Degree of concentration. The feed material, or concentrate, must contain a high percentage of soluble solids to prevent spattering and loss of solids during the early stages of drying. Orange concentrates with 60% solubles handle satisfactorily *(26)*. Feeds containing 70% are preferable provided they are sufficiently fluid to flow evenly on the trays or belts. These feeds not only contain less water to be evaporated but puff more uniformly.

Tomato pastes up to 40% solids were used in our work *(11)*. Pastes of higher density were too thick to handle. Lemonade concentrate was standardized at 65.7° Brix, by the addition of sugar *(17)*. Feed material having a concentration range below 60% soluble solids, besides causing excessive spattering during the early drying stages, also necessitates a longer drying cycle to obtain a suitable product. Feed concentrations much above 66% soluble solids are not advisable (because of the slow solubility of sucrose) at the maximum temperature at which the feed material can be held during mixing without incurring flavor damage.

A general criterion applicable to most concentrates used in the production of powders is that they contain the highest percentage of solids consistent with high quality and suitable fluidity for ease of handling.

Suspended pulp. Excessive pulp in the feeds inhibits or even prevents puffing during dehydration. Orange concentrates with not more than 12% (by volume, when diluted to single-strength juice) have dried satisfactorily *(26)*. All commercial samples of concentrated orange juice that were used were satisfactory so far as pulp content was concerned.

Tomato pastes or concentrates containing 20-25% pulp were used to produce powders that reconstitute readily to full-bodied juices *(11)*. The nature of this pulp seems to be critical for a powder that will reconstitute completely with a minimum of stirring. A high percentage of intact cells in this pulp is desirable. Tomato pastes with a pulp predominantly consisting of broken cells have not made powders with good reconstitution characteristics.

Pectin content. Tomato concentrates produced under conditions that result in a high pectin content yield powders with good reconstitution characteristics. Tomato powder made from low-pectin tomato paste would not reconstitute to a good juice, nor was this fault overcome by the addition of pectin.

Entrained gases. Incorporation of air into the feed, as may result during the mixing of the concentrate, increases puffing during drying. Excessive amounts of air in orange concentrate result in some loss of solids by foaming during early stages of dehydration. Deaeration may even be necessary.

Experience has shown that for batch drying it is

[a] Presented at the 16th Annual Meeting of the Institute of Food Technologists, St. Louis, Mo., June 13, 1956.

necessary to incorporate finely dispersed air into the tomato concentrate *(11)*. Without the additional air, tomato pastes with normal amounts of pulp do not expand as does orange concentrate.

Unstable constituents. Citrus concentrates as normally produced contain appreciable quantities of essential oils that contribute a great deal to the flavor of the reconstituted juices. Unfortunately some of these oils may be unstable under the storage conditions imposed on the powders *(15)*. For this reason the oil content of citrus concentrates used for powders should be as low as feasible. To make up for the resulting lack of flavor in the powder, the oil is replaced by methods to be discussed later.

ADDITION OF STABILIZING ELEMENTS

It is well known that addition of certain sulfur compounds to commodities being dehydrated has improved both color and stability of product. For example, apricots, peaches, and pears are sulfited to preserve the light natural color of the fruit. The natural or bleached raisins have been similarly treated before drying. Some of the vegetables dehydrated are sulfited, for example cabbage, carrots, and potatoes.

Small amounts of sulfur dioxide as sodium bisulfite (about 200 p.p.m.) added to samples of orange juice containing 60% orange and 40% corn sirup solids were rather strikingly effective in reducing the rate of deterioration of powder during storage at elevated temperatures *(15)*. In both sulfited and nonsulfited samples, visible nonenzymatic browning, as measured by optical density, was extremely slight. It is quite possible, however, that only a small amount of browning is sufficient to result in undesirable off-flavors, or that colorless compounds formed by interaction of various constituents may be responsible for the undesirable off-flavors that develop during storage at elevated temperatures. The development of off-flavor is known to be retarded by sulfur dioxide.

The addition of 0.05% sodium bisulfite to tomato paste improved stability during drying. This resulted in about 400 p.p.m. of SO_2 in the powder, which was near or below the taste threshhold for even the most critical panel members, since the concentration of SO_2 in the reconstituted product was only about 20 p.p.m. *(11)*.

The addition of sugars (sucrose and dextrose) and corn sirup solids to the feed material serves to facilitate drying, improve the product's handling, and increase storage stability. Lemon juice powder, without these additives, turns brown in storage. So far 100% lemon powder has not proved as stable as orange or tomato powder.

At first we were able to produce orange powder only with the addition of 40% corn sirup solids. Improvements in drying techniques, incorporation of sulfite, and control of feed material have made it possible to produce 100% orange juice powder as well as a number of other juice powders.

PUFF-DRYING TECHNIQUES

Several techniques have been used for producing fruit and vegetable juice powders. We have tried puff-drying in a vacuum, spray drying, drum drying, and grinding of dehydrated material in piece form. Puff-drying was found to be most desirable for the juices studied; it can consistently produce powders high in quality coupled with a high product yield.

The term "puff-drying" has been selected for the method of dehydrating liquid materials in vacuum by evaporating water from the liquid state under pressures in excess of 1 mm. of Hg in such a manner that the products puff during drying, and form expanded, honeycombed structures. This process is distinguished from freeze-drying in that the latter is done under extremely low pressures, always well below 1 mm. and sometimes as low as 5 microns. The capacity of a given installation for puff-drying is several times as large as a freeze-drying plant of the same size and cost, because of the much greater volumes of water vapor at the low pressures required for freeze-drying.

While work at the Western Branch on puff-drying has contributed greatly to the successful commercial application of this process, considerable basic information had already been developed by earlier research workers. One of the earlier references to puff-drying is the patent which was granted to Heyman *(9)* in 1943. He claimed a method of producing a solid dehydrated citrus product which comprised mixing citrus fruit materials with corn sirup, expanding the mix under heat and vacuum, and dehydrating the mix to form an expanded dehydrated cellular product having intercommunicating cells.

An important contribution to powder technology was made by the Massachusetts Institute of Technology under contract to the U. S. Quartermaster Corps during World War II *(13)*. Workers at the National Research Corporation and Vacuum Food Corporation also contributed materially as indicated by the following brief references. Hays and co-workers *(5, 6)* reported in 1946 on the puff-drying of 50° Brix orange-juice concentrate in a laboratory vacuum oven at the extremely low pressure of 100 microns. Powders reconstituted readily and were judged superior to canned juices but not as good as fresh juice.

Schroeder, Cotton, and others *(2, 19, 20, 23, 24)* reported in 1948 on further studies in which the liquid was sprayed on a plate. Within a short time, the film would swell and puff as much as 3 inches. The vacuum would range from 600 microns down to 300 microns or less at the end of the drying cycle. It was determined that drying from a liquid film doubles the production rate compared with a frozen film. Drying temperatures under 120° F. were recommended.

Of considerable importance in the successful commercial application of puff-drying has been the availability of suitable equipment. Vacuum shelf driers were used in our laboratory experiments. Vacuums to 1-mm. pressure are readily achieved. Heating and cooling of the shelves, as required by the process, are performed satisfactorily. Batch-type driers, of course, have limited commercial application although some have been developed and used very successfully for certain products. A beverage powder, for example, has long been produced in this type of drier. Low-moisture fruits also have been produced on specially built batch driers.

A continuous belt-type dehydrator designed for orange juice drying was described by Sluder in 1947 *(25)*. An endless stainless-steel belt was housed within an evacuated chamber. Radiant heat and conduction were used for drying the thin film of concentrate. The

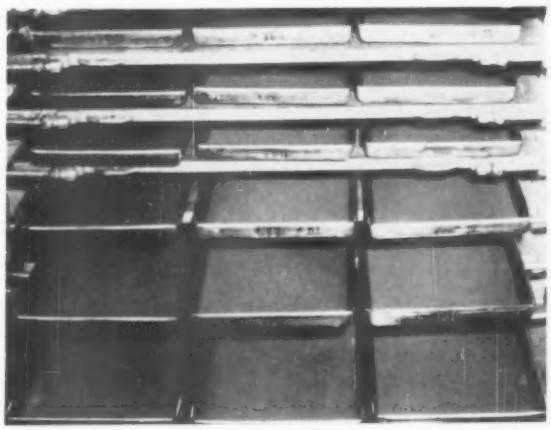

Figure 1. Experimental production of orange-juice powder. The trays have been placed on shelves of a vacuum drier.

concentrated orange juice puffed while drying. The powder was vacuum packed without exposure to air.

Some soluble coffee is now produced commercially in continuous belt-type dehydrators. We used a pilot-scale model of such a drier in the first successful continuous dehydration of 100% orange and tomato-juice powders, using basic data from our batch-type laboratory operations. The adaptation of the puff-drying technique to continuous operation was made possible by the cooperation of the Chain Belt Company in permitting test runs in their equipment and assisting in the operation *(29)*. A large model of their drier is now producing citrus powders in Florida.

Research at the Western Branch on puff-drying procedures has contributed the following essential data discussed in the remainder of this section, to the successful production of fruit and vegetable powders.

Figure 2. Vacuum-dried orange concentrate is removed from trays.

Vacuum requirements. Pressures as high as 4 mm. of Hg have been used to dry orange concentrate. At higher pressures, puffing during drying is not uniform. More rapid drying and somewhat greater expansion can be obtained at a pressure of 1 to 2 mm. of Hg *(26)*. Tomato concentrate can be dried in batch-type driers at 3 mm. of Hg *(11)*, but the drying time can be cut in half at 1 mm. of Hg and the product reconstitutes much more readily. A somewhat higher vacuum was found necessary for lemonade powder. At pressures above 2 mm. of Hg a poor puff, irregular drying, and wet spots resulted at a shelf temperature of about 160° F. *(17)*. Thus we have demonstrated that puff-drying can be carried out at reasonably high pressures that do not require such an excessive capital investment in contrast to pressures used in freeze-drying and some previous puff-drying research. Pressures used in some of the continuous drier runs differed materially from those used in the vacuum shelf driers. Tomato powder was produced at 2.5 to 6 mm. Below 2.5 mm. too much ice was present in the feed for satisfactory application to the drier belt.

Time-temperature drying cycle requirements. Drying should be carried out in a time-temperature cycle that will not result in heat damage to the product. The temperature should, on the other hand, be as high as possible to permit most economical operation. It was found that orange solids can be held safely at a finishing temperature of 140° F. for 50 to 60 minutes with little heat damage. It has also been found that considerably higher temperatures can be safely employed to shorten the drying cycle, provided the equipment permits sufficient rapid cooling so that the orange solids are not held too long at these higher temperatures *(26)*.

In the drying of tomato solids, product temperatures above 150° F. caused heat damage. With the addition of 0.05% sodium bisulfite to the paste prior to drying, the maximum product temperature without heat damage was at least 190° F., and drying time, in a shelf drier, could be reduced from 2½ hours to about one hour.

Lemonade powder was dried at a shelf temperature of 160° F. for most of the drying period. Raising the shelf temperature from 160° to 180° F. early in the cycle was designed to yield maximum evaporation rate compatible with viscosity requirements and avoidance of flavor damage. Product temperature approached 160° F. in 2 hours *(17)*.

Extent of dehydration in the drier. We have found that it is practical to dehydrate the powders to about 3% moisture in the drier. At the temperature limitations for each product, the time required to reach this moisture content was reasonable. Schroeder *(19)* showed that even at the low pressure of 200 microns, with the heat sources at 113° F., it took 50 hours to dry orange powder from 3% to 1% moisture content. In contrast, he dried 50% orange concentrate to 3% moisture content in 5 hours at the same temperature. Moisture content could be brought to 1% or lower in the drier at a more rapid rate if high temperatures could be used. The time cannot be reduced sufficiently, though, so that no heat damage results.

INCORPORATION OF FLAVORING COMPONENTS

It is necessary to add flavoring components in stabilized form to most of the fruit powders for at least two important reasons: (a) Some flavor constituents are highly volatile and are lost during drying. Thus, if the raw product does not have an exceptionally strong or durable flavor, the powder will be lacking in flavor. (b) Some flavoring materials are not stable in the dry powder during storage. Orange oil, for example, undergoes oxidative changes if it is exposed to air.

Thus the problem becomes twofold: obtaining the desired flavoring components having the necessary quality, and putting them into a form so that they will remain stable throughout the necessary storage period and be available for flavoring the reconstituted juice. Depending upon the product, we have used two types of flavoring material: volatile flavoring constituents obtained from the raw-product juices and citrus oils obtained from the peel of the fruit.

The recovery of volatile flavoring constituents was reported in 1946 by workers at the Eastern Utilization Research Branch *(14)*. Further research at the Western Branch resulted in the development of a process for stripping the volatiles by steam injection *(1)*. Among the fruit juices from which volatile flavoring components have been stripped are apple, grape, berry, and pineapple.

The procedure used by the Western Branch on Concord grape juice was briefly as follows *(22)*: The volatile flavors were vaporized from the juice and concentrated 330-fold.[b] The flavoring components were extracted from this aqueous flavor concentrate with isopentane. Since the amount of flavoring component was small, and some of the constituents were quite volatile, it was considered advantageous to add an edible, high-boiling, water-insoluble extender to the extract before boiling off the iso-pentane. A vegetable oil was used for this purpose. In boiling off the iso-pentane, a 14,000-fold nonaqueous flavor concentrate was obtained. This vegetable oil solution of flavor was found suitable for incorporation with solid carriers.

We are studying different vegetable oils to determine which are most stable and desirable for this purpose. We are also working to reduce losses in present methods of concentrating flavor. With citrus fruits, the recovery and concentration of volatile flavor from the juice is unnecessary, inasmuch as high-quality cold-pressed oils have been found to be quite satisfactory flavoring agents *(18)*.

The second problem in adding flavor to powder is to put it in a stable form so that the constituents will be available to flavor the reconstituted juice. Probably the first requirement is to remove them from contact with oxygen. The most practicable means of achieving this is to lock them in a solid carrier. The properties required in a carrier include edibility, rapid solubility in water, insolubility in oil, and ability to solidify in a continuous and stable form without cracks or fissures. Furthermore, the carrier must impart no flavor to the product.

[b] The fold number, as used here, is the ratio of weight of original juice to weight of corresponding flavor concentrate.

Griffin *(4)* developed a process for incorporating oils and related products into sorbitol. In early work at the Western Branch the sorbitol was melted, the oil added, and the mixture stirred vigorously. The material was then ground to desired fineness, vacuum treated to remove the surface oil, and added to the powder.

The flavoring material, which is either a citrus oil or a vegetable oil solution of a natural fruit flavor, is present in minute globules distributed throughout the interior of the grains, and thus the product is called "locked flavor." The concentration of flavoring oils in most of our preparations is in the range of 4 to 7%. About 1 to 3 grams of the product are equivalent to the flavor from 1 liter of juice. Organoleptic tests of orange powders showed that the addition of oil in solid carriers resulted in a product having a better flavor than the product from concentrate to which oil had been added directly *(15)*.

We have found the use of sorbitol as a carrier satisfactory in many respects, but its usefulness is limited to the meta-stable crystalline form. If it changes to the stable crystalline form, fissures develop, permitting access of oxygen to the flavoring oil, and this leads to off-flavor. Also, in this condition, the flavoring oil is subject to loss by volatilization.

Other materials were tried as carriers. The use of dextrose and sucrose has proved quite promising. Sugars would appear to be good for this purpose because of their solubility in water and because they are natural constituents of fruits. In our work on incorporating orange oil in both dextrose and sucrose *(21)*, it was found that flavors locked in dextrose should be kept in the amorphous state as the orange oil is locked in much better. Protection from moisture is an important factor in maintaining this condition and in preventing stickiness.

As a further means for prevention of crystallization, the use of other sugars and related compounds with dextrose was investigated *(21)*. Of the substances tried, corn-sirup solids proved to be the most effective crystallization inhibitor. Corn sirup serves the same purpose with preparations in which sucrose is the main ingredient.

LOW MOISTURE CONTENT IN PRODUCT

The moisture content of the powder is the most important factor contributing to the storage stability of orange powder *(15)*. Early organoleptic data for orange powder indicated that most of the undesirable flavor changes resulting from storage at 100° F. took place during the first 30 days of storage after conditioning, while the moisture content was being reduced from about 1.4% to 0.5%, and after that time little additional deterioration occurred. Thus for prolonged storage at 100° F., a moisture content of about 0.5% is indicated.

Although tomato powder at 2.5% moisture stored satisfactorily at 70° F., lower moisture levels are necessary if storage temperatures of 90° F. to 100° F. are used *(30)*. Moisture contents of 0.4% or lower were achieved in storage at 90° and at 100° F. through the use of an in-package desiccant. At these moisture levels

and with an inert atmosphere, untoward changes in flavor and ascorbic acid content were prevented and nonenzymatic browning repressed.

The packaging of powders in a vacuum or inert atmosphere has had considerable study at the Western Branch. Improvement of storage stability has resulted in some instances.

IN-PACKAGE DESICCATION

The very low moisture ranges required for fruit and vegetable powders, generally below 1%, can be achieved in either the dehydrator, over a rather long period of time, or in the can with the use of a desiccant. Attaining the desired moisture level in the dehydrator has two major drawbacks: (a) The time required is considerable; thus a large investment in equipment would be necessary to achieve the desired production capacity. (b) There is danger of heat damage when the product is subjected to the necessary drying temperature over the long drying period necessary to reach the low moisture levels.

Attaining moisture levels in dehydrated products lower than can be advantageously reached in the dehydrators has been the subject of research for some years. Commercial vegetable dehydrators use "finishing bins" in which the product is placed. The bed depth may be several feet. Drying is carried out for up to 36 hours at reasonably low temperatures and moderate air flow. At the Western Branch the "fluidized-bed" drier was developed for the final drying step in the production of potato granules *(16)*.

In-package desiccation (IPD) has proved extremely successful in bringing the moisture level of dehydrated products (in piece or powder form) to very low levels at a moderate cost and with little if any product deterioration. With IPD, a product is sealed in a hermetic container along with a desiccant—so that moisture can be transferred during storage from product to the desiccant. A water-vapor-permeable package for the desiccant prevents it from contaminating the product *(28)*.

Work on IPD has been carried out by the Western Branch during and since World War II. First we were concerned with the dehydrated vegetables purchased by military agencies. Recently we have studied IPD with respect to the new food powders. Among the problems that arise the following are perhaps most significant: choice of the desiccant, choice of container for desiccant, and rate of desiccation to be achieved.

Desiccant. A desiccant must have high-vapor capacity per unit weight and volume at the relative humidity to be maintained within the package. In addition, it must have a fairly high rate of hydration at the desired humidities, and must be a non-toxic, odorless, low-in-cost, and non-deliquiscent solid *(7, 28)*. Perhaps most important is the first factor mentioned, a high water-vapor capacity. To reduce moisture content to below 1%, orange powder requires a desiccant with high hydration capacity at below 5% relative humidity. In a relative humidity of 5%, most desiccants absorb only about 5% of their weight of water.

Calcined lime absorbs about 32% of its weight of water. It thus has excellent water-vapor capacity, and it will essentially maintain 0% humidity until completely converted into calcium hydroxide. The high absorptive capacity of lime makes it possible to reduce moisture content of dehydrated foods by several percent without a prohibitive sacrifice in container volume.

Calcined lime that does not expand beyond 90% on hydration is recommended. For this reason, recalcined hydrated lime is preferred. One type of recalcined lime expanded only 60% while gaining 32% in weight. Ten of 11 commercial samples of calcined lime had expansions of over 100%. The other sample had an expansion of 70% and therefore would meet the requirements of IPD *(7)*.

Desiccant container. To be satisfactory, the desiccant container must be siftproof, accommodate expanding desiccant, provide reasonably low resistance to transmission of water vapor, and resist abrasion and puncturing. On the basis of tests carried on at the Western Branch, it was concluded that chipboard containers, canvas bags, and jean-cloth bags with paper liners are satisfactory desiccant containers, provided they are large enough to contain the expanded lime *(28)*.

A new lower-cost desiccant container has been developed, consisting of a double-creped kraft paper forming the envelope. Coated with a heat-sealing material on one side, it is suitable for high-speed forming machines.

Because calcium oxide expands upon hydration, the container material should be able to expand or stretch. Indented stretchable heat-seal bags have resisted failure from expanding lime much better than have comparable nonindented bags *(7)*.

Rate of desiccation. The rate at which the product loses moisture with IPD depends upon: moisture content of the product, absorption capacity and rate of hydration of the desiccant, temperature, and amount of product in the container. Generally, we are considering powders being packed at 3% moisture content and a final moisture content for storage at under 1%.

The temperature at which the product is held is very important in determining the rate of desiccation. Tomato powder, starting at 2.8% moisture, was reduced to about 1% moisture in 3 weeks at 100° F., in 6 weeks at 90° F., and in 12 months at 70° F. *(30)*.

If the product is to be stored at an elevated temperature, such as 90 or 100 F., a question that arises is whether the product should be held at a lower temperature until the moisture content reaches a level sufficiently low so that heat damage does not occur. This is under investigation at the present time. Although earlier investigations indicated a need for a conditioning period, there is evidence that in certain cases a conditioning period may not be necessary. At the elevated temperature, the product reaches the desired low moisture content so quickly that little deterioration, if any, takes place over that which would have occurred at a lower temperature but longer time.

OTHER METHODS OF MAKING POWDER

Spray drying. The spray-drying of fruit and vegetable juice powders has also been studied extensively. Citrus powders with large quantities of additive to

facilitate drying and handling have been produced commercially for several years. To date no one has demonstrated a commercially feasible process for spray-drying of fruit and vegetable juice powders without use of additives. The hygroscopic nature of the powders and ease of heat damage place severe limitations on conditions that may be used.

The pilot plant work at Western Branch has made some important advances on the spray-drying of tomato powder *(12)*. The spray drier used, although large for an experimental unit, appears inadequate for proper drying and collection of this product. Tests on larger units of various designs will be necessary to evaluate some drier design characteristics further. Experimental runs have also been made with citrus juices, prune purees, and other products with which small amounts of additives have been included.

Agitated film-type evaporator. A new approach to the production of fruit and vegetable powders is being developed on a laboratory scale at the Eastern Utilization Research Branch *(3)*. In this process sugar is added to a juice concentrate and the water is then evaporated from this material in an agitated-film type of evaporator. Temperatures are sufficiently high to keep the material fluid, even when the moisture content is down to 2.5%. A very short retention time is necessary to minimize heat damage. In laboratory runs, flavor essences in a highly concentrated form and with sugar added were mixed with the molten dry product as it left the evaporator. The product was hardened on a chilling roll and then ground into a powder.

ECONOMIC CONSIDERATIONS

If the fruit and vegetable powders are used for beverages, it is likely that they will compare very favorably pricewise with the canned single-strength juices. It appears that tomato juice powder from the West Coast could undersell, in an Eastern market, canned single-strength tomato juice from the same area. This, of course, is dependent upon the successful development of large-scale procedures for producing this powder.

Cost comparisons of powders with juice concentrates are more difficult and should be evaluated for each specific case. In some of our preliminary estimates, we have not found cost differences sufficiently large to appear to be a major factor in the acceptance of juice powders. The distinct physical advantages of powdered products will be important enough so that the products may be preferred and used in some marketing outlets.

Perhaps the most serious cost competition will come from powders made from sugars and other solids and synthetics or even natural flavoring components and nutritional factors. It is, therefore, essential that the natural fruit and vegetable juice powders have the highest possible quality and contain the important nutritional elements, and at the lowest possible cost.

FUTURE DEVELOPMENTS

The developments described have been used to make orange, grapefruit, grape, pineapple, tomato, and prune extract powders. The production of 100% orange and grapefruit powders has now been reduced to commercial practice. One company is currently building a plant to make tomato powder; other companies are making puff-dried lemonade powder and pineapple powder on a pilot scale.

A market for puff-dried fruit and vegetable juice powders such as have been discussed is assured by the following important attributes. These powders have natural flavor combined with attractive appearance, especially good color. They are convenient to handle and use. They are versatile, being adaptable for use in various products in both dry and reconstituted form. Their reduced weight and bulk assure savings in package, storage, and transportation costs. And last, and perhaps most important of all, these puff-dried powders have excellent storage stability without refrigeration.

The puff-dried powders will find outlets in civilian, export, and military markets. For direct use in the retail markets, for example, the powders can be used as reconstituted juices. They can also be mixed with other ingredients and packaged as dry soup, stew, sauce, and relish mixes.

The remanufacturing trade can utilize the puff-dried powders in a number of ways: for beverages, sauces, pastes, catsup, purees, ice cream mixes, and bakery goods. These powders can readily be used in the manufacture of canned and frozen foods such as soup concentrates, sauces, and combination dishes.

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Effect of Additives and Blanching on the Quality of Processed Whole-Kernel Sweet Corn[a, b]

Robert C. Wiley

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In canned and frozen whole kernel sweet corn there is the problem of nutrient, flavor, and weight losses from the freshly-cut kernels due to extensive contact with water and brines in such operations as fluming, washing, blanching, processing and subsequent storage.

Lindquist and co-workers *(3)* have reported that blanching on the cob prior to cutting, compared with blanching of cut kernels has improved the quality of frozen whole-kernel sweet corn.

The purpose of this work is to investigate the effects of certain edible film formers which could be used to seal the freshly cut kernels and preserve their respective nutrients through both canning and freezing procedures and subsequent storage. These treatments have been compared with samples blanched on the cob, off the cob, and those with minimum contact with water.

MATERIALS AND METHODS

Varieties. Three varieties Tendermost, Sweetangold, and Illinois 13 (a shoepeg type) were grown at the Department of Horticulture Plant Research Farm in 1954.

These three varieties were chosen for the study because of their difference in seed configuration which would possibly have an effect on losses from the cut kernels. (Figure 1.)

Stage of maturity. Each variety was harvested at a medium fancy and low extra standard stage of maturity as determined by the trimetric sweet corn maturity test *(2)*.

About 400 ears of each variety were harvested at each respective maturity.

Raw product preparation. The corn was husked in a F.M.C. double husker and then the ears were washed in a rotary washer The unblanched ears were then passed through a TUC corn cutter which on one side contained a 7/8-inch cutter opening (deep cut), on the other a 1 1/8-inch cutter opening (shallow cut).

Method of treatment. The freshly cut kernels of treatments 1-8 were then placed in pans containing about one gallon of the test solutions. The kernels were stirred and kept in contact with the various solutions for 4 minutes.

Code of the treatments studied:

1. 2% $CaCl_2$ solution
2. 2% Low methoxy pectin solution
3. 2% Carboxy methyl cellulose solution
4. 2% $CaCl_2$ + 2% Low methoxy pectin solution
5. 2% $CaCl_2$ + 2% C.M.C. solution
6. 2% L.M. pectin + 2% C.M.C. solution
7. 2% $CaCl_2$ + 2% L. M. pectin + 2% C.M.C. solution
8. H_2O soak (Check A)
9. The cut kernels were lightly rinsed in water. (Check B)
10. The kernels were blanched after being cut from the cob for 2½ minutes in steam.[c]
11. Ears of corn were blanched on the cob 6-8 minutes and then cut.

Figure 1. Seed configuration of the three varieties.

Processing Procedures. The cut treated kernels were lightly washed, drained, and weighed into their packages—7 ounces for each No. 1 C enamel can and 10 ounces per frozen food package. The cans were filled with 180° F. 2% salt brine.

Each was processed according to regular commercial procedures. In the case of the frozen samples treatments 1-9 were blanched 2½ minutes in steam. None of the samples canned were blanched except treatments 10 and 11.

The canned product was held for 3 months at room temperature and the frozen pack was held about 4 months in 0° F. storage before laboratory analysis.

Laboratory analysis. The following analyses were carried out on each processed container—264 packages in all for the canned and frozen pack.

Canned samples

1. % total sugars *(1)*
2. Drained weight *(5)*
3. % total solids kernel portion
4. % total solids liquid portion
5. % soluble solids liquid portion

[a] Scientific Article A578, Contribution No. 2741 of the Maryland Agricultural Experiment Station (Department of Horticulture).

[b] Presented at the Sixteenth Annual Meeting of the Institute of Food Technologists, St. Louis, Missouri, June 11, 1956.

[c] This treatment was an unblanched sample in the frozen corn study (supposed simulation of raw cut kernels).

Frozen samples

1. % total sugars *(1)*
2. Drained weight *(4)*
3. % total solids kernel portion
4. % total solids liquid portion

Sensory evaluation. The canned and frozen samples were presented to a group of 6 trained judges who by the multiple comparison or variables method rated the samples for flavor (sweetness) and a so-called "hollowed out" kernel factor on a 1-10 basis, 10 being *perfect* and 1 *very poor*.

Statistical evaluation. This three variety (seed configuration), *2* maturity, *2* depth, 11 treatment balanced factorial experiment was analyzed completely by analysis of variance.

RESULTS AND DISCUSSION

The results of variety (seed configuration), maturity and depth will be noted for the various quality measurements but the main emphasis will be placed on the effects of the various treatments on the quality of the processed kernels.

Canned corn. *Percent total sugars.* As shown in Tables 1 and *2* variety (seed configuration), maturity, depth, and treatment significantly affected the total sugars in canned whole kernel corn. Illinois 13 (1.15), Tendermost (1.00), and Sweetangold (0.99) ranked 1, *2*, 3 in sugar content. The extra standard maturity (0.93) contained less sugar than fancy (1.17) and the deep cut (1.08) more than the shallow cut (1.01).

Variety X maturity and variety X depth interactions were significant indicating the varieties reacted differently to different maturities and depths of cut.

Additive treatments, 1, *2*, 3, 4, 5, and 6 or blanching on the cob were not significantly higher in sugar than Check treatment A (8) or Check treatment B (9). Blanching after cutting from the cob was significantly lower than all treatments in percent total sugars at the 1% level. Blanching on the cob was significantly higher in sugar than treatments *7* and 10.

Drained weight. Also in Tables 1 and *2* variety (seed configuration), maturity, and treatment significantly affected the drained weight of canned whole kernel corn. Illinois 13, Tendermost and Sweetangold ranked 1, *2*, 3 in drained weight. The extra standard corn gave a higher drained weight than the fancy pack.

Variety X maturity interaction significance indicated one variety increased more in drained weight than another with advancing maturity.

Check A and B were not significantly different and treatments 1-*7* were not significantly higher in drained weight than either check.

Blanching on the cob was significantly higher in drained weight than all other treatments at the 5% level. This amounted to an increase of 4% over the mean drained weight of the other treatments.

Treatment 10 blanched after being cut from the cob was significantly lower than treatments 1, *2*, 5, 8, 9, and 11 at the 1% level.

Percent total solids kernel portion. As seen in Tables 1 and *2* variety and maturity significantly affected the total solids content of the canned kernels. Treatment and depth have no significant effect. Illinois 13, Sweetangold and Tendermost ranked 1, *2*, 3 in percent total solids. The extra standard corn was higher in solids than the fancy.

The variety X maturity interaction significance indicated a different rate of increase in total solids among the varieties.

No statistical significance could be demonstrated among the total solids of the 11 treatments.

Percent total solids liquid portion. It was felt by examining the percent total solids of the liquid portion an estimate of leaching in storage could be determined.

As seen in Tables 1 and *2* maturity and treatment affected significantly the liquid total solids at the 1% point. Variety was significant at the 5% point but depth had no apparent effect on solids content of the liquid. Total solids in the liquor increases with maturity. Illinois 13, Tendermost and Sweetangold ranked

TABLE 1

Mean values of the various determinations

Factors	Canned					Frozen			
	% total sugars	Drained wt. (gms.)	% total solids kernels	% total solids liquid	% soluble solids liquid	% total sugars	% drained wt.	% total solids kernels	% soluble solids liquid
1—Treatment									
1	1.10	217.0	21.25	5.58	5.10	3.18	94.14	27.65	4.70
2	1.06	218.0	21.00	5.59	5.10	3.10	93.16	29.25	4.55
3	1.09	213.3	21.85	5.59	4.95	3.00	92.88	28.18	4.60
4	1.03	216.1	21.80	5.42	5.00	3.18	93.87	28.83	4.30
5	1.05	217.1	21.74	5.32	5.10	3.06	93.85	27.73	4.40
6	1.06	212.5	21.46	5.49	5.00	3.14	94.56	27.62	4.55
7	1.02	212.7	21.01	5.38	5.05	2.88	93.50	27.66	4.25
8	1.05	218.8	22.05	5.27	4.90	2.94	93.18	28.07	4.20
9	1.07	219.8	21.92	5.67	5.30	3.30	93.83	28.03	4.60
10	0.86	210.0	21.35	4.89	4.40	3.86	90.42	30.31	8.90
11	1.14	224.4	21.65	5.48	5.00	3.86	97.29	29.39	6.66[1]
L.S.D. for treatment									
5%	.11	4.5	—	.22	.21	.26	1.54	1.72	.48
1%	.15	6.1		.30	.28	.35	2.05	—	.68
2—Variety									
Tendermost	1.00	215.06	19.72	5.39	5.05	3.22	92.20	26.10	5.00
Sweetangold	0.99	214.41	20.27	5.37	4.90	2.84	93.87	27.01	4.50
Illinois 13	1.15	219.63	24.67	5.52	5.00	3.62	95.04	32.18	5.30
3—Maturity									
Fancy	1.17	211.21	19.26	4.97	4.60	3.40	92.50	27.16	4.65
Extra Standard	0.93	221.53	23.85	5.88	5.40	3.06	94.80	31.70	5.10
4—Depth									
Shallow	1.01	ns	ns	ns	ns	ns	ns	27.82	4.80
Deep	1.08	ns	ns	ns	ns	ns	ns	29.04	5.00

[1] Average of only 6 values.

TABLE 2

Mean square values of the various determinations

Factors	d/f	Canned					Frozen			
		% total sugars	Drained wt. (gms.)	% total solids kernels	% total solids liquid	% soluble solids liquid	% total sugars	% drained wt.	% total solids kernels	% soluble solids liquid
Treatment	10	.058**	192.44**	1.58	.56**	128.7**	1.73**	31.12**	9.55*	52.57**
Variety	2	.36**	356.60**	324.43**	.32*	118.0**	8.69**	89.25**	473.18**	14.01**
Maturity	1	1.69**	3513.40**	694.65**	27.00**	4860.0**	4.82**	182.95**	1410.09**	13.88**
Depth	1	.15**	1.30	.23	.01	0.0	.04	9.60	49.42**	2.89*
Treatment × Variety	20	.0095	23.34	1.53	.16*	17.0	.15	4.65	2.04	.58
Treatment × Maturity	10	.003	40.99	3.76	.17*	8.9	.48**	5.41	6.15	1.21
Treatment × Depth	10	.003	33.27	1.44	.12	12.4	.04	2.53	9.52	.21
Variety × Maturity	2	.225**	641.60**	57.33**	6.23**	1377.5**	3.01**	152.62**	149.29**	44.20**
Variety × Depth	2	.06*	81.60	1.42	.24*	227.5**	.72**	23.43**	21.80*	1.21
Maturity × Depth	1	.01	47.20	.76	.62**	197.0**	.03	.17	4.98	3.39*
Total	131									

* Significant at the 5% level.
** Significant at the 1% level.

1, 2, and 3 in percent total solids in liquid. Apparently the variety that contained the highest percent total solids of the kernel also had the highest liquid total solids.

Variety × maturity, maturity × depth, variety × depth and maturity × treatment interactions were significant indicating a great deal of variability was present in the various factors which effect liquid total solids.

The sample blanched in steam (4.89% solids) was significantly lower than all other treatments in liquid solids. Treatments 5, 7, 8, 9, and 11 were not significantly different in liquid total solids which indicates no particular advantage in blanching on the cob to reduce leaching during storage.

Percent soluble solids of liquor. This test was also used to determine if leaching in storage could be reduced by any of the treatments. In Tables 1 and 2 variety (seed configuration), maturity and treatment significantly effected percent soluble solids at the 1% level. Tendermost, Illinois 13 and Sweetangold ranked 1, 2, and 3 in soluble solids of liquor. The soluble solids were higher in the liquor of extra standard than the fancy maturity pack.

Variety × depth and variety × maturity interaction were significant at the 1% level indicating the varieties responded differently to depth and maturity.

There was no significant difference between treatments 1, 2, 3, 4, 5, 6, 7, and 11 which show no advantage to blanching on the cob from this aspect.

The sample blanched off the cob was significantly lower than all other treatments in percent soluble solids of the liquor.

Check treatment B (9) was significantly higher than treatment 8 and treatment 11.

Sensory Evaluation. There were no significant flavor or "hollowed out" kernel factor differences among treatments.

Frozen corn. *Percent total sugars.* In Tables 1 and 2 variety, maturity, and treatment had a significant effect on percent total sugars of frozen corn. Illinois 13 (3.62), Tendermost (3.22), and Sweetangold (2.84) ranked 1, 2, and 3 in sugar content. The fancy corn had a higher sugar content (3.40) than the extra standard corn (3.06).

Variety × maturity, variety × depth and maturity × treatment interactions were significant at the 1% level.

Treatment 10 and 11 were significantly higher (3.86) than all others in percent total sugars. Treatment 9 which was only lightly washed was significantly higher than treatments 7, and 8 and the same as treatments 1-6, at the 5% level. These last treatments afforded the same protection against sugar loss as an unwashed but blanched sample.

Drained weight as percentage of put-in weight. Drained weight of frozen corn (Tables 1 and 2) is significantly affected by variety (seed configuration), maturity, and treatment. Illinois 13 (95.04), Sweetangold (93.87), and Tendermost (92.20) ranked 1, 2, and 3 in drained weight. The drained weight of extra standard corn (94.80) was higher than that of fancy (92.50).

The variety × maturity and variety × depth interaction were also significant.

Drained weight of treatment 11 was significantly higher than any of the other treatments at the 1% level. The drained weight was 97.3% or 4% higher than the mean (93.3) of the other 10 treatments. Treatment 6 although significantly lower than 11 at the 1% level was significantly higher than treatments 3 and 10 and was numerically higher than Check B, the unwashed sample. The unblanched sample (90.41) showed considerable breakdown and was significantly lower than all treatments at the 1% level with a 10% loss from the original weight of corn placed in the frozen package.

Percent total solids kernel portion. Variety and maturity as shown in Tables 1 and 2 have a highly significant effect on total solids in the kernel with variety Illinois (32.18), Sweetangold (27.01), Tendermost (26.10) ranking 1, 2, and 3. The extra standard corn averaged 31.70% solids while the fancy corn averaged 25.16% total solids.

Treatment was significant at the 5% level.

Variety × maturity and variety × depth interactions were also significant.

There was no significant difference between the checks and treatments 1-7. The sample blanched on the cob was the same in total solids as treatments 2, 3, 4, 5, 8, and 9, which were blanched for 2½ minutes in steam after cutting from the cob.

The nonblanched sample (simulated fresh sample) showed the highest total solids of 30.31% but was not significantly different from treatments 2, 4, and 11.

Percent soluble solids liquid portion. As seen in Tables 1 and 2 variety, maturity, depth, and treatment

had a significant effect on the percent soluble solids of the liquor from the drained frozen corn. Variety Illinois 13, Tendermost and Sweetangold ranked 1, 2, 3 in percent soluble solids of the liquid portion. The extra standard corn showed a higher percent soluble solids than the fancy. The deep cut had a higher solids content than the shallow cut.

The variety × maturity and maturity × depth interactions were significant. Treatment 10 exhibited the highest percent soluble solids value which was significantly higher than all other treatments. This indicates considerable physical breakdown in this unblanched sample. Although there was a significant difference between Check A and Treatment 1, none of the other additives reduced the loss from leaching in the frozen corn.

Sensory Evaluation. As seen in Table 3 treatments 2, 4, 5, and 6 are not significantly different in flavor

TABLE 3

Mean sensory panel scores (flavor) of frozen corn for the 11 treatments

Treatments										
1	2	3	4	5	6	7	8	9	10	11
6.01	6.58	6.24	6.86	6.53	6.86	6.09	6.21	6.06	3.02	7.58

L.S.D. for treatment:
5% 1.23

from the samples blanched on the cob. Samples 1, 3, 7, 8, 9, and 10 were significantly lower in flavor than the sample blanched on the cob at the 5% level.

There were no significant differences between treatments in the "hollowed out" kernel factor. Sample means ranged from 7.95 for treatment 4 to 6.98 treatment 10.

SUMMARY AND CONCLUSIONS

Canned Corn

1. There was no significant difference in percent total sugars among the additive treatments, the controls, and the sample blanched on the cob. Treatment 10, the sample blanched 2½ minutes in steam after cutting, was significantly lower in sugar than all treatments and controls at the 1% level.
2. None of the additives and controls could be demonstrated as being statistically the same in drained weight as the treatment blanched on the cob. This treatment showed a significant increase of 4% in drained weight above the mean drained weights of the 10 other treatments. Steam blanching of cut kernels was significantly lower in drained weight than 7 out of the 11 treatments at the 1% level.
3. Treatments and blanching techniques used had no significant effect on the percent total solids of the processed kernels.
4. None of the additives or blanching on the cob could be demonstrated as reducing leaching in storage.
5. There were no significant differences in flavor and the "hollowed out" kernel factor among the various treatments.

Frozen Corn

1. Percent total sugar in the corn blanched on the cob and the unblanched sample were identical and significantly higher than any of the other treatments. Treatments 1-6 were not significantly different from Check B, a lightly washed sample. Treatment 7 and Check A were significantly lower than Check B at the 1% level.
2. The drained weight of frozen corn blanched on the cob and then cut showed a significant increase of 4% over the mean value of the other 10 treatments.
3. There was no significant difference in percent total solids of the kernels among treatment 2, 2% L.M. pectin, treatment 4, 2% $CaCl_2$ and 2% L.M. pectin, treatment 11, blanched on the cob and treatment 10, the unblanched sample which had the highest percent total solids in the kernels.
4. Treatment 2, 2% L.M. pectin, treatment 4, 2% $CaCl_2$ and 2% L.M. pectin, treatment 5, 2% $CaCl_2$ and 2% C.M.C. and treatment 6, 2% L.M. pectin and 2% C.M.C. were not significantly different in flavor (sweetness) from the sample blanched on the cob. There was no significant difference among treatments as measured by the "hollowed out" kernel factor.

Variety (seed configuration) had a very pronounced effect on the factors studied, with canned corn the highest quality at equal grade levels was in Illinois 13, second—Tendermost and third—Sweetangold. In frozen corn Illinois 13 was also highest with Sweetangold and Tendermost alternating depending on the factor studied.

Maturity had a very important effect on quality with the fancy packs sweeter but lower in drained weights and percent total solids.

The deep cut samples were generally higher in sugar and drained weights.

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Effects of Gamma Radiation on the Pectic Constituents of Fruits and Vegetables[a, b]

F. J. McArdle
Michigan State University, East Lansing, Michigan, and
J. V. Nehemias
Fission Products Laboratory, University of Michigan, Ann Arbor, Michigan

(Manuscript received July 24, 1956)

SOFTENING OF MANY FRUITS AND VEGETABLES by ionizing radiations is one of the problems encountered in employing the radiation process to extend the storage life of fresh produce *(2)*. When the chemical changes involved in softening of fruit and vegetable tissues by radiation have been determined, methods for retarding this undesirable reaction might be developed. Since tissue firmness is attributed largely to intercellular pectic substances *(7)* a study was made of the changes which occur in the pectic constituents of fruits and vegetables irradiated with gamma rays. Such information would contribute to a better understanding of the effects of radiation on foods and it might be of value in furthering successful application of radiation processing to fresh produce.

Softening of plant tissue has been correlated with pectic changes by numerous studies of physical and chemical changes in fruits and vegetables under various conditions. A conversion of protopectin to soluble pectins and a reduction of total pectin substances have been associated with the softening of vegetables during cooking *(5)*, with texture changes in fruit during maturation *(11)*, and with texture changes in fruit during storage *(1, 6)*. In every case, as the pectic materials were converted to less complex units, a decrease in firmness of the plant tissue was apparent.

The effects of radiation on starch containing cells of the potato tuber have been studied by Roberts and Proctor *(4)*. Using micro chemical methods they reported an alteration in the pectinaceous materials of the middle lamellae, which resulted in a softening of the tissue. Unlike the action of heat, irradiation did not cause a breakdown of the cellulose containing cell structure or change the form of the starch granules. No quantitative measure of texture changes or pectic alterations were reported.

Pectic transformations were implicated in radiation induced softening of fruits and vegetables. This investigation was undertaken to determine quantitatively the effects of gamma radiations on pectic constituents of apple and carrot tissue.

EXPERIMENTAL

Jonathan apples from the departmental storages were used in this experiment. Carrots were purchased fresh through the University Food Stores. All irradiations were performed by gamma rays from the Cobalt-60 source at the University of Michigan. Apples were irradiated at 0, 0.5×10^6, 1.0×10^6 and 1.5×10^6 rep; carrots at 0, 0.5×10^6, 1.0×10^6, 1.5×10^6 and 2.0×10^6 rep. Each treatment consisted of 8 to 10 randomly selected fruit or roots.

Quantitative texture measurements. Apple textures were determined with the Magness-Taylor pressure tester using a $\frac{7}{16}$ inch head. Carrot texture was estimated from Tenderometer readings of 100 g. of $\frac{1}{4}$ inch diced cubes of the roots.

Extraction and precipitation of pectic substances. Pectic substances were extracted and precipitated by the methods outlined by Kertesz *(1)*.

A 500 g. sample of apple or carrot tissue was used for each determination. The weighed tissue was sliced into boiling 95% ethanol. The alcohol volume was predetermined to give a final mixture containing 70% alcohol. The mixture was simmered for 5 minutes, allowed to stand for 18 hours, and then further dehydrated with 95% ethanol and ether. The alcohol insoluble solids were dried at 140° F. (60° C.) and pulverized in a Wiley mill.

The alcohol insoluble residues were extracted twice with water to remove pectin, extracted twice with 0.5% ammonium oxalate to remove pectate, and finally extracted twice with 0.05M hydrochloric acid at 185° F. (85° C.) to remove protopectin. Each of the 3 extracts was precipitated by adding two volumes of 95% ethanol containing a quantity of hydrochloric acid calculated to make the total volume 0.05M hydrochloric acid. The precipitates were collected on hardened filter paper using suction. The precipitates were washed with 70% ethanol, dried at 167° F. (75° C.), and then weighed. The pectic substance content of apple and carrot tissues were expressed as milligrams per 100 grams of fresh material.

Relative viscosity measurements. One percent aqueous solutions of the precipitates at pH 6.0 were used for determining relative viscosities. Cannon-Fenske modified Ostwald viscosimeters were employed at 86° F. (30° C.).

Calcium pectate content of precipitates. Purity of the alcohol precipitates was determined by the calcium pectate method of Poore *(3)*.

RESULTS AND DISCUSSION

Changes in texture of apple tissue exposed to various gamma ray doses are shown in Figure 1. The values shown for each treatment are averages from 10 fruit. Three determinations were made on each fruit. Figure 2 shows the effects of gamma radiation on carrot

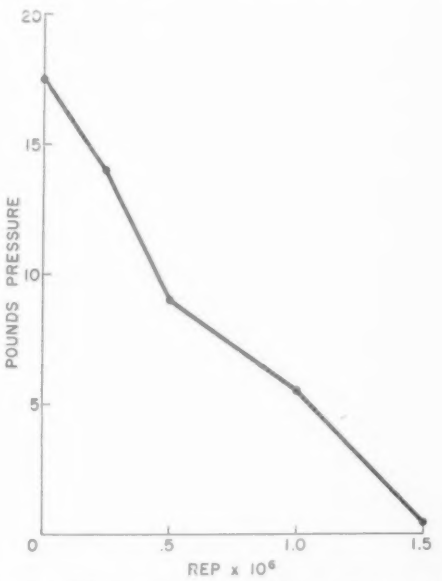

Figure 1. Effect of gamma radiation on texture of apple tissue.

[a] Journal Paper No. 1926, Michigan Agricultural Experiment Station, East Lansing, Michigan.

[b] Presented before the Sixteenth Annual Meeting of the Institute of Food Technologists, St. Louis, Missouri, June 13, 1956.

tissue. The values are averages of 3 determinations on representative samples from each treatment.

Resistance of carrot tissue to texture change by irradiation is greater than that of apple tissue. This greater resistance is due to the presence of considerable amounts of supporting fibers, largely cellulose and hemicellulose, which have been shown to be unaltered by radiation doses of 2.0×10^6 rep *(4)*.

Protopectin, pectate, and pectin content of gamma irradiated apple and carrot tissue are shown in Figures 3 and 4, respectively. In both cases, a breakdown of protopectin to pectates and soluble pectin occurred. A decrease in total pectic substances, which is the sum of the 3 fractions, indicated a breakdown of pectin and pectates to simpler non-pectic materials. The most extensive changes occurred in the protopectin component which was almost completely destroyed at the highest dose levels. Since insoluble pectic materials maintain cellular adhesion in plant tissues, the destruction of protopectin by ionizing radiations appears to be the cause of radiation induced softening of fruits and vegetables. Alteration of protopectin in the intercellular areas allows the tissue cells to separate and loss of texture results.

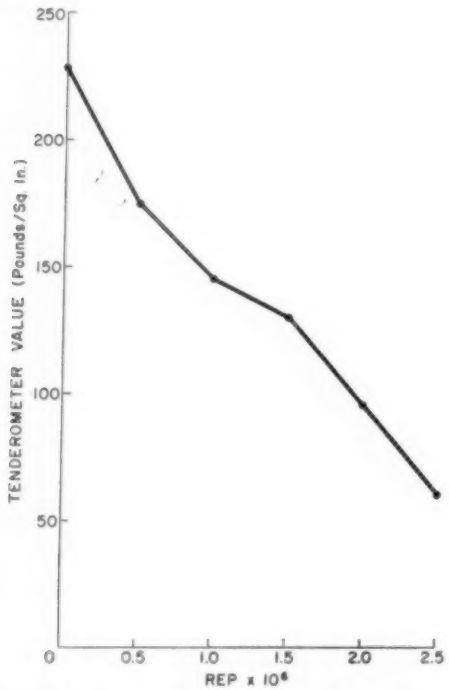

Figure 2. Effect of gamma radiation on texture of carrot tissue.

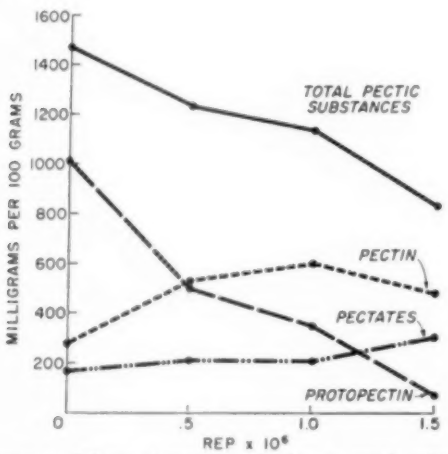

Figure 3. Effects of gamma radiation on pectic substances in apple.

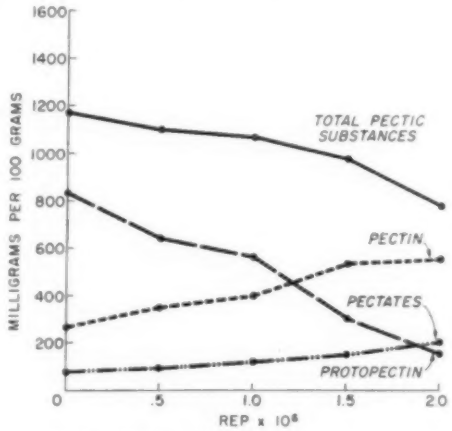

Figure 4. Effects of gamma radiation on pectic substances in carrot itssue.

Relative viscosities of the 3 pectic fractions from irradiated apple and carrot tissue are shown in Table 1. The viscosity decrease of all fractions indicated that depolymerization occurred during irradiation. A destruction of all pectic substances probably took place simultaneously, but protopectin, having the most complex molecular structure, was reduced most rapidly.

Table 2 shows the percent calcium pectate content of the various pectic fractions. The values ranged from 77 to 90%, meaning that 77 to 90% of the alcohol precipitates were pectic substances. The radiation treatments did not significantly alter purity of the precipitates.

TABLE 1

Relative viscosity changes in pectin, pectate, and protopectin from gamma irradiated apple and carrot tissue

Radiation dose (Rep x 10^6)	Pectin		Pectate		Protopectin	
	Apple	Carrot	Apple	Carrot	Apple	Carrot
0	2.17	1.84	2.02	1.80	1.79	1.69
0.5	1.73	1.62	1.67	1.61	1.38	1.52
1.0	1.48	1.56	1.46	1.49	1.23	1.31
1.5	1.32	1.37	1.25	1.33	1.17	1.27
2.0		1.19		1.21		1.12

TABLE 2

Percent calcium pectate content of alcohol precipitates from gamma irradiated apple and carrot tissue

Radiation dose (Rep x 10^6)	Pectin		Pectate		Protopectin	
	Apple	Carrot	Apple	Carrot	Apple	Carrot
0	88.72	84.51	90.29	86.62	87.72	89.24
0.5	78.42	87.42	84.41	80.51	89.12	80.74
1.0	85.17	82.93	86.67	85.41	85.24	83.27
1.5	83.31	79.21	79.21	77.84	80.71	77.31
2.0		80.72		78.34		82.31

SUMMARY

A relationship is indicated between radiation induced softening of apple and carrot tissues and the changes which occurred in the pectic substances. Gamma radiation caused a decrease in protopectin and total pectic substances. Soluble pectin and pectates increased. These changes were accompanied by depolymerization of the pectin, pectate, and protopectin molecules as indicated by a decrease in relative viscosity of the 3 fractions.

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Characteristics of Electron-Irradiated Meats Stored at Refrigerator Temperatures[a]

J. F. Kirn, W. M. Urbain, H. J. Czarnecki
Research Laboratories, Swift & Company, Chicago, Ill.

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In recent years considerable interest has developed in the use of ionizing radiation for the sterilization of foods. The literature on radiation as a means for preserving food without cooking has developed rapidly, especially that pertaining to the immediate effects of irradiation on the color, odor, and flavor of foodstuffs. However, little information has been published pertaining to the physical changes and the keeping qualities of irradiated meats stored for extended periods of time.

Pratt and Eklund *(3)* have briefly reported on the storage of beef irradiated with gamma rays at 2,000,000 rep. Their beef was stored for a period of 5 months at 5°, 22° and 37° C. Brownell *et al. (1)* reported the properties of beef stored for a period of one month at 37° C. after a gamma irradiation at 3.5 million rep. Hannan *(2)* reported on the odor and visual changes which take place in irradiated beef on storage for 2½ years, but did not taste his products.

When we entered into an extensive irradiation program several years ago, one of our first experiments was designed to evaluate the keeping qualities of irradiated meats from different species of animals, including both skeletal and organ meat cuts, and with different methods of processing. This paper reports some of our findings.

PROCEDURE

Meat cuts from different animal types were selected for quality and variety, and were obtained in both the fresh and cured condition. They were placed in hermetically sealed containers (cans) prior to irradiation. The methods for processing are outlined in Table 1. The irradiation procedures were carried out in the laboratories of Electronized Chemicals Corporation, using a 2,000,000 volt Capacitron electron generator as the radiation source. The amount of radiation was controlled to give an internal dose of either 1.45 million rep or 2 million rep at the center of the can. The samples were refrigerated during the irradiation with either water ice or dry ice to maintain temperatures at 1° C. for unfrozen samples and —29° C. for the frozen. After irradiation the samples were stored at 7° C.

The samples were evaluated organoleptically initially in the first or second day following irradiation by a panel, usually of six members. Each sample was graded according to pigment color, odor, and flavor based on a scale of 9 and 10 for *excellent*, 7 and 8 *desirable*, 5 and 6 *acceptable*, 3 and 4 *poor*, 1 and 2 *very poor* or *repulsive*. The samples were prepared for the taste panel evaluation by heating the precooked irradiated samples in an oven until thoroughly warm or in the case of raw pork sausage, hamburger, bacon or steak, by broiling.

Subsequent evaluations were made as indicated in Table 2.

RESULTS

Color. Initially, the red pigments of all the canned raw meats showed irradiation damage but recovered on storage until all products other than beef liver exhibited desirable pigmentation. All raw beef and beef products were given lower numerical grades than were given to comparable pork or pork products. Beef, both broiled and roasted, showed abnormal change of the pigment with time from the usual brown cooked appearance to a bright pink color. Surface pigments were quite unstable in air and faded after a few minutes.

Cooked pork and veal, as well as lamb, showed similar tendencies to take on this pink pigmentation with time but not to the same degree as did beef.

Texture. The products, both the precooked and the raw processed samples, were in general of very good texture. Beef liver, the one exception, exhibited a state of extensive shrinkage with the expression of con-

[a] Presented at the Sixteenth Annual Meeting of the Institute of Food Technologists, St. Louis, Missouri, June 13, 1956.

TABLE 1

Preparation procedure

No.	Product	Preparation	Can type[1]	10^6 Rep	Refrigeration (during irradiation)
1	Beef Steaks (with salt)	6 mm. thick sirloin strip, raw	TDT	2	Ice Chilled
2	Beef Steaks	6 mm. thick sirloin strip, raw	TDT	2	Ice Chilled
3	Hamburger	6 mm. thick, ground beef, raw	TDT	2	Frozen
4	Hamburger	Broiled to medium, well done, internal temperature of 68° C.	Aluminum	1.45	Ice Chilled
5	Hamburger	6 mm. thick, .1% deoxygenase and glucose hamburger, raw	TDT	2	Ice Chilled
6	Hamburger	6 mm. thick .1% monosodium glutamate, raw	TDT	2	Ice Chilled
7	Hamburger	6 mm. thick .1% succinic acid, raw	TDT	2	Ice Chilled
8	Hamburger	6 mm. thick, .25% sodium ascorbate and citric acid, raw	TDT	2	Frozen
9	Beef Roast	Roasted to internal temperature of 60° C. Rib roast	Aluminum can	1.45	Ice Chilled
10	Veal	Roasted, well done to internal temperature of 82° C. Cut 9.6 mm. thick	Aluminum can	1.45	Ice Chilled
11	Pork	Roasted, well done to internal temperature of 88° C. Cut 9.6 mm. thick	Aluminum can	1.45	Ice Chilled
12	Lamb	Roasted, well done to internal temperature of 85° C. Sliced 9.6 mm. thick	Aluminum can	1.45	Ice Chilled
13	Chicken	Cooked thoroughly to internal temperature of 88° C. Both white and dark meat included	Aluminum can	1.45	Ice Chilled
14	Liver, Beef	9.6 mm. sliced fresh, raw	Aluminum can	1.45	Ice Chilled
15	Pork Sausage	Bulk sausage, raw	Aluminum can	1.45	Ice Chilled
16	Pork Sausage	Cooked, well done, 9.6 mm. thick	Aluminum can	1.45	Ice Chilled
17	Corned Beef Hash	Hash containing potatoes, onions, salt, pepper, sugar and curing ingredients. Heated at 81° C. to an internal temperature of 68° C.	Aluminum can	1.45	Ice Chilled
18	Ham	Cut 9.6 mm. thick	Aluminum can	1.45	Ice Chilled
19	Bacon	Two strips, raw	Aluminum can	1.45	Ice Chilled
20	Cured Pork Shoulder, comminuted	9.6 mm. thick. Cooked to minimum of 57° C.	Aluminum can	1.45	Ice Chilled
21	Franks	Cooked, 9.6 mm. thick	Aluminum can	1.45	Ice Chilled

[1] TDT designates the tin plate thermal death time can obtained from the American Can Company having the following dimensions:—diameter 63.5 mm., depth 9.5 mm. Aluminum cans were of Norwegian manufacture and had the following dimensions:—diameter 81.0 mm., depth 11.1 mm. Both cans were lacquer lined. Only the TDT cans were vacuum closed.

siderable meat juices. There was evidence of protein change in the raw beef samples which manifested itself after extensive storage as small needle-like crystalline clusters, particularly in the connective tissues. X-ray diffraction and ultra-violet absorption investigations proved the material to be pure L-tyrosine. While found extensively throughout raw beef product, this crystalline amino acid was almost entirely absent from raw pork and was completely absent from all precooked product.

Flavor. In general, irradiated meats have a tendency to recover flavorwise as well as colorwise on holding under anaerobic conditions. The improvement was found to take place over a period of 10 to 30 days; however, further aging did not improve the quality. Pork, lamb, and chicken showed the smallest flavor changes and decreasingly so in the order listed.

Beef products, raw, cooked, cured or salted all exhibited an extremely bitter flavor in addition to those flavors usually attributable to irradiation.

Chicken, lamb, fresh pork, and bacon were not bitter, nor did they have a bitter after-taste. These products did have a slight irradiated flavor but were considered not too "objectionable" by the taste panel. The cooked lamb was described as being "strong" in flavor.

DISCUSSION

The bacon, raw and precooked pork sausage, precooked lamb and chicken were in remarkably good condition for 5-year-old canned meat products. The containers showed no evidence of being attacked by the product and lacked the metallic taste quite frequently associated with long time canned meats. It should be pointed out that storage of these products was at 7° C. which temperature-wise is a relatively mild condition. Storage at 7° C. probably prevented the growth of certain bacteria and this could be considered as an atypical circumstance. However, it avoided any hazard to the tasters from *Cl. botulinum* or other potentially dangerous organism in the event that the irradiation process did not accomplish sterilization. It was believed that useful information could be developed despite these relatively mild storage conditions.

An explanation for the extreme bitterness in raw beef samples was sought. The fatty acids and Initial Peroxide Values as determined by the method of Rockwood *et al. (4)* (Table 3) indicated that the flavor as scored by the panel did not show any regular correla-

TABLE 3

Comparison of free fatty acid and peroxide values with flavor scores after 1800 days storage at 7° C.

No.	Product	% Free fatty acid	Peroxide values milli-equivalent per 1000 g.	Flavor score
1	Beef with salt	4.6	2.3	2.5
2	Beef without salt	5.7	2.5	2.75
3	Hamburger, raw	13.0	3.0	3.5
4	Hamburger, broiled	10.6	2.3	2.25
5	Hamburger + Deoxygenase + Glucose	7.9	4.7	5.4
6	Hamburger .1% Monosodium Glutamate	13.9	2.7	2.2
7	Hamburger, .1% Succinic Acid	11.8	1.2	2.0
8	Hamburger, .25% Sodium Ascorbate and Sodium Citrate	12.1	3.4	2.5
9	Beef, Roast	3.0	2.4	4.2
10	Veal, Roast	16.8	7.7	5.0
11	Pork, Roast	1.0	0.92	6.7
12	Lamb, Roast	1.5	15.0	5.3
13	Chicken, Roast	1.4	71.4	5.2
14	Liver	13.0	2.1	1.5
15	Pork Sausage (raw)	4.3	19.2	6.5
16	Pork Sausage (cooked)	2.7	0.59	7.0
17	Corned Beef Hash	5.8	18.0	3.25
18	Ham	13.4	34.0	3.75
19	Bacon	13.7	0.52	5.5
20	Cured Pork Shoulder	2.8	89.6	3.75
21	Franks	2.6	5.0	4.25

TABLE 2

Organoleptic evaluation results

No.	Product[1]	Appearance	Aroma	Flavor
1	Beef steaks with salt			
	Control	7.5	8.5	9.3
	+ 1 day	3	7.5	5.0
	+ 1800 days	8	2	2.75
	Remarks: Bitter, metallic			
2	Beef steaks without salt			
	Control	7.5	8.5	9.0
	+ 1 day	1.8	7.5	7.5
	+ 1800 days	5	2	2.5
	Remarks: Bitter, metallic			
3	Hamburger, raw			
	Control	8.5	9.0	9.0
	+ 1 day	3.3	2.5	4.0
	+ 1800 days			3.5
4	Hamburger, broiled			
	Control		4.0	5.2
	+ 1 day		3.6	3.2
	+ 30 days		4.0	5.0
	+ 1800 days	7.0	5.0	3.5
	Remarks: Extremely bitter			
5	Hamburger and deoxygenase and glucose			
	Control		7.5	7.3
	+ 1 day	2	5.0	4.8
	+ 1800 days	5.4		5.4
	Remarks: Bitter after taste			
6	Hamburger + .1% MSG			
	Control	9.0	9.2	9.3
	+ 1 day	6.8	4.3	2.0
	+ 1800 days	8.0		2.2
	Remarks: Bitter			
7	Hamburger + 1% succinic acid			
	Control	9.0	9.2	9.3
	+ 1 day	9.0	9.2	
	+ 1800 days	6.8		7.0
8	Hamburger + .25% sodium ascorbate and citric acid			
	Control	8.5	9.0	9.0
	+ 1 day	2.5	3.0	5.0
	+ 1800 days	6.4		2.5
	Remarks: Very repulsive			
9	Beef, Roast			
	Control	8.0	8.8	9.6
	+ 1 day	8.0	6.0	6.4
	+ 10 days		7.4	5.8
	+ 21 days		5.4	4.4
	+ 60 days		4.8	4.0
	+ 1800 days	8.0	8.0	4.2
	Remarks: Irradiated scorched flavor			
10	Veal, Roast			
	Control		8.0	8.6
	+ 2 days		5.4	4.0
	+ 11 days		4.4	4.0
	+ 30 days		5.8	4.4
	+ 1800 days	8.0	4.5	5.0
	Remarks: Slight irradiated flavor			
11	Pork, Roast			
	Control	8.6	9.4	9.4
	+ 1 day	8.6	4.0	2.6
	+ 12 days	8.0	5.4	4.0
	+ 31 days		7.0	7.6
	+ 1800 days	8.3	7.0	6.7
	Remarks: Very slightly irradiated flavor			
12	Lamb, Roast			
	Control		9.0	8.8
	+ 2 days		6.8	2.6
	+ 11 days		4.4	4.0
	+ 30 days		7.0	6.6
	+ 1800 days	8.0	5.5	5.3
	Remarks: Strong lamb flavor			
13	Chicken, Roast			
	Control		9.6	9.0
	+ 1 day		5.0	2.0
	+ 10 days	3	4.4	5.0
	+ 1800 days	8	6.0	5.2
	Remarks: Irradiated or scorched flavor			
14	Liver, Beef			
	Control	8	10	10
	+ 2 days		8.0	7
	+ 17 days		8.0	7.4
	+ 1800 days	0	4	3
	Remarks: Repulsive, bitter			
15	Pork Sausage, raw			
	Control	6	8.8	6.4
	+ 2 days	6	8.4	6.4
	+ 15 days	8	8.0	8.0
	+ 26 days	8.6	7.0	6.6
	+ 1800 days	1	6.0	6.5
16	Pork Sausage, cooked			
	Control	9.6	9	8.6
	+ 1 day	8.6	5.6	4.8
	+ 10 days		9.0	5.6
	+ 20 days		8.6	8.0
	+ 1800 days	5	9.0	6.5
17	Corned Beef Hash			
	Control		9.0	9.0
	+ 2 days		6.0	6.0
	+ 1800 days	7		3.3
	Remarks: Bitter after flavor			
18	Ham			
	Control	10	10	10
	+ 1 day	2	2	2
	+ 13 days		7.0	4.4
	+ 1800 days	7		3.8
	Remarks: Very bitter, metallic irradiated			
19	Bacon			
	+ 26 days	8	5.3	3.6
	+ 1800 days	7	6	5.5
	Remarks: Slightly irradiated			
20	Cured Pork Shoulder			
	Control	10	8.4	9.0
	+ 1 day		2.6	2.0
	+ 15 days		3.6	4.0
	+ 36 days		5.0	5.0
	+ 1800 days	8	6.0	3.7
	Remarks: Bitter			
21	Franks			
	Control	10	10	10
	+ 1 day	12	2	2
	+ 1800 days	5.3	8.0	4.2
	Remarks: Oxidized or irradiated flavor			

[1] The control was not irradiated. The other samples were irradiated and stored for approximately the additional days indicated.

tion with quantities of either free fatty acids or peroxides present in the product. The bitter flavor seemed to correspond approximately to the amount of tyrosine present on the surface of the meat. Since tyrosine is tasteless, however, the bitter flavor must be due to other factors.

In conclusion it can be stated that meat samples which have had some heat processing prior to irradiation yielded the more desirable product on long storage.

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A Continuous Process for Dehydrating Fruit Juices[a]

Victor A. Turkot, Roderick K. Eskew and Nicholas C. Aceto

Eastern Regional Research Laboratory,[b] Philadelphia 18, Pennsylvania

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IN THE FOOD FIELD concentrated and dehydrated products are assuming a position of ever-increasing importance. Witness the growth in frozen juice concentrates, powdered coffee, soup mixes, and dehydrated mashed potatoes, to name a few. In keeping with this trend, powdered fruit juices of late have been the object of very considerable interest. At least one company has been producing powdered citrus juices commercially *(7, 10)*. The U. S. Army Quartermaster Corps is particularly interested in the use of fruit juice powders because of their light weight and excellent keeping properties.

A batch technique for the preparation of powdered apple and grape juice products using vacuum shelf-drying has already been described by the authors *(5, 9)*. Juice reconstituted from these powders possesses excellent flavor, and storage tests show that when packaged with a desiccant the powders keep satisfactorily for over a year at 73° F. (22.8° C.) and over 6 months at 100° F. (37.8° C.) *(12)*.

THE PROCESS

Because vacuum shelf-drying is a relatively expensive batch operation, continuous methods of drying were investigated. The continuous belt, high-vacuum type drier used to produce citrus juice powders commercially could probably be used for the noncitrus juices. However, this type of drier is relatively expensive and is best suited to large-scale production. Also many of the noncitrus juices do not require high vacuum as they are less heat sensitive. A different approach was, therefore, taken in this work.

In the process developed, sweetened juice concentrate is quickly dried under moderate vacuum and at high temperature to a moisture content of 2 to 2½% in a special type of evaporator while remaining in a molten state. It is pumped out of the evaporator, mixed with a metered quantity of high-fold essence,[c] and chilled quickly on rolls to form thin brittle flakes which, after crushing, constitute the final product. One gallon of high-fold essence contains the aromatic volatile flavoring constituents of about 1000 gallons of fresh juice. The finished powders yield reconstituted juices which have pleasing natural color, flavor, and aroma.

A small integrated prototype plant using this continuous process has been operated at the Eastern Regional Research Laboratory with a production rate of thirty pounds of powder per hour. So far this pilot plant has produced powders from apple, Concord grape, and Montmorency cherry juices, and its use will also be extended to other fruit juices.

The flow sheet (Figure 1) and photographs (Figures 2 and 3) depict the continuous evaporative drying process and equipment. In the following description the numbers are those appearing in these figures. The most important piece of equipment is the mechanically agitated thin-film evaporator (No. 4).

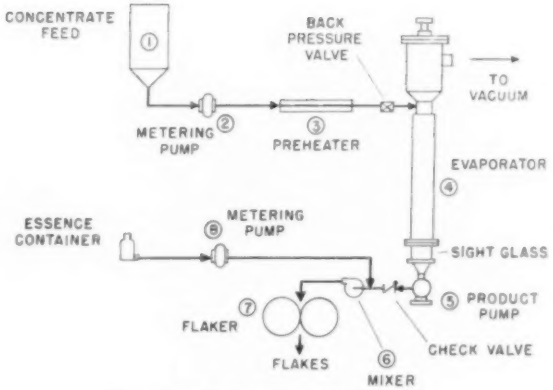

Figure 1. Flow sheet of the process.

Various designs are offered by several firms in the United States; the one used in these studies was a laboratory-size unit of the Turba-Film Evaporator[d] manufactured by the Rodney Hunt Machine Company of Orange, Massachusetts. This evaporator consists of a vertical hollow cylinder with a jacket; within the cylinder rotates an agitator having three straight vertical fins or blades. These blades clear the wall by about 0.030 inch and serve to keep the material being processed in a thin turbulent film against the wall. The agitator r.p.m. can be varied between wide limits. The discharge end of this evaporator was changed somewhat from the original design in order to facilitate flow of the very viscous molten product. This result was achieved by replacing a 1-inch diameter outlet tube with a 3-inch diameter sightglass above a short cone that extends right to the inlet of the discharge pump. On a commercial-size unit this modification might be unnecessary. Feed from a tank (No. 1) is metered by a pump (No. 2) through a preheater (No. 3) and enters the top of the evaporator. It flows down the inner wall by gravity, at the same time being carried around the wall by the action of the agitator, so that it actually descends in a flat spiral path to the bottom of the tube. The feed makes only a single pass; by the time it reaches the bottom of the tube it is fully concentrated. It drops through the sightglass and is discharged by a positive delivery pump (No. 5). Immediately downstream from the pump a sufficient quantity of approximately 1000-fold essence is injected continuously into the pipeline carrying the concentrate so that the ratio of essence constituents to solids is about the same as it is in fresh juice, assuming no losses during processing. The product enters a centrifugal pump (No. 6) whose function is to insure complete mixing and is then fed into the nip of a pair of revolving chilled metal rolls (No. 7) which reduce it to small brittle flakes approximately 0.015 inch thick. Approximately 100 seconds after the feed enters the evaporator it is delivered from the rolls as dried flakes. The flakes are coarsely crushed and then sealed in 4-ounce cans with an inpackaged desiccant[e] *(5, 6, 9, 11, 12)*.

To prevent the hygroscopic dried products from picking up moisture and caking, all operations in which the flakes or

[a] Presented at the 16th Annual Meeting of the Institute of Food Technologists, St Louis, Missouri, June 12, 1956.

[b] A laboratory of the Eastern Utilization Research Branch, Agricultural Research Service, U. S. Department of Agriculture.

[c] Essence is an aqueous concentrate of the naturally occurring volatile flavoring constituents obtained from fresh juice by a process developed at the Eastern Regional Research Laboratory *(8)*.

[d] Mention of trade name or company in this paper does not imply it is recommended or endorsed by the U.S.D.A. over others not mentioned.

[e] Nine grams of pelleted calcium oxide (Desiccite 30 made by Filtrol Corp.[d]) in a heat-sealed envelope of dust-tight, vapor-permeable paper (Promset 831-X made by Mid-States Gummed Paper Co.[d]).

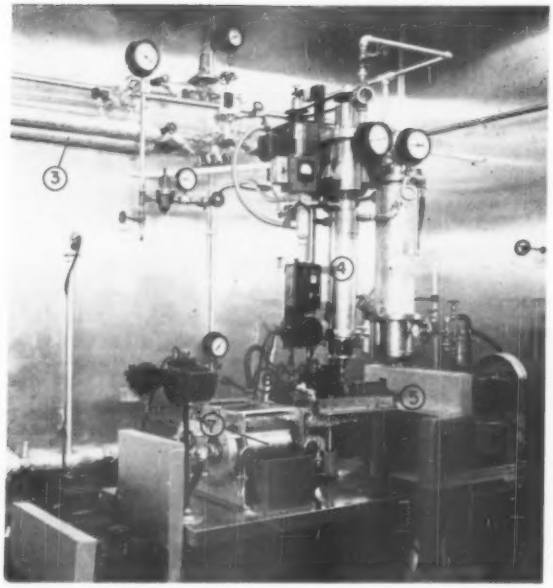

Figure 2. General view of apparatus. 3, preheater; 4, evaporator; 5, product pump; 6, centrifugal (pump) mixer; 7, flaking rolls.

powder are exposed to the atmosphere are carried out in a room where the relative humidity is maintained at about 10%.

PREPARATION OF FEED MATERIAL

Juice concentrate. The starting material for making the powders was the juice itself. Apple juice was prepared from purchased apples; grape juice came from commercial suppliers, either hot packed or frozen; and the cherry juice was a commercial frozen pack. It is believed that freshly prepared or frozen juices are preferable to the hot packed as they can be expected to tolerate more heat treatment during later processing without damage.

The juice is first stripped of essence in a continuous "essence recovery unit" (*2, 3, 4*). The juice now stripped of its volatile aromas is enzyme-depectinized, filtered, and evaporated under vacuum to about 75% solids. Sugar (sucrose) is added in amount equal to 100% of the juice solids for apple, 50% for grape, and about 50% for cherry. This sucrose is added for several reasons: (*1*) it decreases the hygroscopicity of the material, making it easier to dry and to handle after drying; (*2*) it raises the softening temperature of the product making it less susceptible to caking in storage; (*3*) it helps retard flavor deterioration because, not entering into the browning reaction itself, it dilutes the monosaccharides and amino acids that interact to damage flavor; (*4*) being cheaper than juice solids, it lowers the cost of the final product. The sugar may either be dissolved in the juice before vacuum evaporation or added to the evaporated concentrate as a 75-80° Brix sirup. With apple and grape juices a small amount of citric or tartaric acid respectively is added to maintain a palatable sugar-acid ratio; with cherry juice this addition is usually unnecessary.

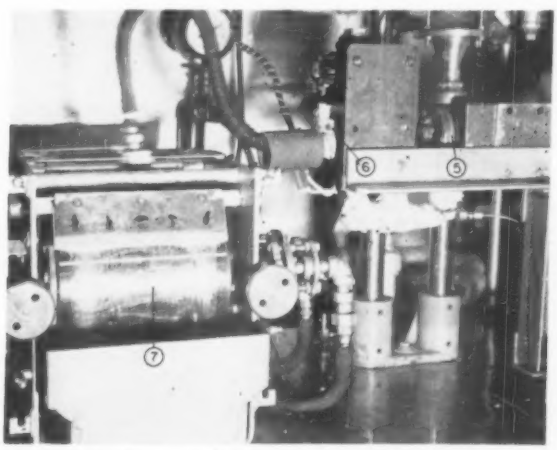

Figure 3. Close-up of apparatus. 5, product pump; 6, centrifugal (pump) mixer; 7, flaking rolls. Essence is introduced through narrow tube at right center.

High-fold essence. To keep the moisture content of the dried product low enough to prevent caking, only a small quantity of aqueous essence may be added to it. To convey enough of the aroma-bearing constituents, the essence must be about 1000-fold. This 1000-fold essence was prepared from the lower-fold essence recovered prior to evaporating the juice to concentrate. The apparatus employed was a 1-inch diameter glass fractionating column, packed with 0.16-inch x 0.16-inch stainless steel Protruded Distillation Packing made by Scientific Development Company.[4] The column was operated with continuous feed and drawoff of products. The height of packing was approximately 46 inches, 18 inches above, and 28 inches below, the feed point. Feed rates ranged from 8 to 16 ml./min. and product rates from 0.6 to 1.2 ml./min. With apple and cherry there was little loss of essence constituents to the column bottoms. With Concord grape a significant amount of methyl anthranilate did appear there, indicating the need for further work on the design of the most suitable column. However, the grape powder, as well as the others containing injected high-fold essence, contained ample natural fruit aroma when reconstituted to beverage and tested organoleptically.

OPERATING CONDITIONS

Data are presented in Table I showing typical values of the operating variables involved. The conditions used were quite similar for all three of the juices. One of the initial difficulties encountered in operating the evaporator was foaming. Excessive foaming causes holdup of concentrate in the evaporator tube and also greatly reduces the discharge rate of the pump with consequent heat damage to the product. To overcome foaming, 33 p.p.m. (based on the solids in the feed) of Dow Corning Antifoam AF Emulsion[4] was added to the concentrate just before use. The mixture was agitated continuously to prevent segregation.

Another problem which had to be overcome was leakage of air into the evaporator through the discharge pump and piping. Such leakage rises through the pump suction opening and prevents the concentrate from entering the pump; the result is prolonged retention in the evaporator and heat damage.

The discharge piping and the pump itself, particularly around the shaft, must be free from leaks before satisfactory operation can be assured.

SIGNIFICANCE

The economic feasibility of drying and marketing fruit juice powders has already been demonstrated in the case of orange and grapefruit. The cost of equipment to dry noncitrus juices by the evaporative technique presented here would be approximately one-fifth the cost of the drying equipment of the same capacity used for making citrus powders. Also the operating cost of the evaporative drying equipment should be at most no higher than that of the dryer used for citrus

TABLE 1

Operating conditions for continuous dehydration of fruit juices using mechanically agitated thin-film evaporator

Operating variable	Setting used in processing of:		
	Apple juice	Grape juice	Cherry juice
Feed			
Sugar addition based on juice solids, %	100	50	50
Brix, ° (= % solids)	75	75	75
Feed rate			
lb./hr.	40	40	40
lb. solids/hr.	30	30	30
Temp. entering evaporator, ° F.	135	135	135
Evaporator			
Rotor r.p.m.	1000	1000	1000
Rotor motor current, amp.	1.9-2.1	1.9-2.1	1.9-2.1
Abs. press., inches Hg	3.0	3.5[1]	3.0
Boiling pt. of water ° F. corr. to abs. press.	115	120[1]	115
Product outlet temp. ° F.	225	232	235
Boil. pt. rise, ° F.	110	112	120
Moist. content, %			
before injecting essence	2.1	2.3	2.1
after injecting essence	2.4	2.5	2.3
Steam on jacket			
p.s.i.g.	8	11	12
° F.	235	241	244
Rel. humidity in room, %	8-10	8-10	8-10
Cooling water temp. in chilling rolls, ° F.	35	35	35

[1] Higher absolute pressure used with grape to off-set its greater tendency to foam.

particularly since the maintenance of high vacuum is not required. This fact coupled with the lower investment in equipment should result in a drying cost per pound of product equal to or less than that for the citrus powders. Therefore, the authors believe the production of full-flavored fruit powders from the less heat-sensitive juices using the evaporative drying technique presented here may hold promise of commercial success.

The physical form of the product from the evaporative process—small thin flakes—is such that a fairly short reconstituting time is achieved along with a desirable high bulk density. This bulk density, about 0.9 g./ml., is about one and one-half times that of powders made in the form of a puff or sponge by puff-drying techniques, and enables the same volume of juice to be reconstituted from a smaller package of powder.

Powders possess a distinct advantage over high-density (7-fold) liquid concentrates in regard to keeping properties at elevated temperature. Powdered apple and grape juice products prepared by the batch method keep for well over a year at 73° F. (22.8° C.) and for over 6 months at 100° F. (37.8° C.) *(12)*. The high density liquid concentrates also keep for a year at 73° F. (22.8° C.) but at 100° F. (37.8° C.) their shelf life is less than two months *(1)*.

Besides their use for reconstituting to beverage drinks, attention has been directed recently toward use of these powders as ingredients of prepared cake and dessert mixes to enhance natural fruit flavor. The powders can also be used for the convenient household preparation of fruit jellies.

SUMMARY

A practical process for continuously drying to powder the sweetened concentrates of apple, Concord grape and Montmorency cherry juices has been developed and successfully operated on a pilot-plant scale with a production rate of 30 pounds per hour. The equipment required is considerably less expensive than either vacuum shelf-driers or the continuous belt, high-vacuum type of drier, and is available as standard commercial units. The products have good flavor, color, and aroma, and their keeping qualities at room temperature and at 100° F. (37.8° C.) are expected to be the same as those of the corresponding vacuum shelf-dried products, which are excellent. Besides their use for reconstituting to beverage, the powders can be used to contribute natural fruit flavor to prepared dessert mixes and to form the base for dry fruit jelly mixes.

Acknowledgment

The authors wish to acknowledge the valuable technical assistance of Mr. Nelson H. Eisenhardt and Mr. Howard I. Sinnamon in carrying out the experimental work on which this paper is based.

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Factors Influencing the Sporadic Development of Discoloration in Canned Wet Pack Shrimp[a]

R. G. Landgraf, Jr.
Metal Division, Research and Development Dept., Continental Can Company, Inc., Chicago, Illinois

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DURING THE PAST FEW YEARS the sporadic occurrence of discoloration has been noted in canned (heat processed) wet pack shrimp. It ranges in severity from a slight grayish cast to a blackening of the entire surface of the meats. In extreme cases black particles may be found suspended in the brine and parts of the container become discolored. Although harmless, this discoloration (principally iron sulfide) of product and/or container has caused serious concern and some financial loss to the packer.

A brief survey of canned shrimp packed in the New Orleans area showed that three forms of discoloration existed. These were:

Product discoloration — "graying." This condition varied from a slight grayish cast to a blackening of the entire surface of the shrimp meat.

Product discoloration — "blueing." This condition occurred on the surface of the meat at the head end of the shrimp usually as a blue spot 1/16 to 1/8 square inch in area.

Container discoloration—This form of discoloration occurred principally on the surface of the inside enamel of the can end adjacent to the headspace area. It has also been noted in various other canned food products. Some of the more recent work on black iron sulfide discoloration has been done by Pigott and Stansby *(1)* on tuna.

Of the three forms of discoloration noted, by far the most prevalent was product graying. Blueing occurred infrequently and even when it did occur, it was not considered as objectionable as either graying or container discoloration. Hence the work reported here deals only with these latter forms of discoloration.

In examining various commercial samples, it was noted that there was a wide variation in the pH and the quality of the shrimp when product graying occurred. It appeared that product condition at the time of packing was one of the most important factors involved in the formation of product graying; hence, experimental packs were made to study the effects of (a) condition of the shrimp when packed, (b) size of shrimp, (c) method of peeling and (d) reduction of product pH with citric acid added to the brine.

EXPERIMENTAL

Experimental packs reported here were made at commercial shrimp canneries in the New Orleans area using commercially caught common white shrimp *(Penaeus setiferus)* and "sea-bobs" *(Xiphopenaeus)*. The third type of shrimp commonly canned commercially in the New Orleans area, "brasilian" shrimp or "brownies,"[b] was not available when these experimental packs were made.

Experimental packs of common white shrimp. The shrimp used in these packs were obtained from a commercial shrimp boat and consisted of one lot of common white shrimp caught by one boat, in one area, during one day's fishing. These shrimp were iced separately from the remainder of the boat's catch, were approximately 24 hours old when received, and were in excellent condition. Six baskets (105 lbs. whole shrimp/basket) were obtained for this experiment. Two baskets of shrimp, one of which was hand peeled and the other machine peeled, were canned immediately. The remaining 4 baskets of shrimp were kept well iced in an insulated storage room. Two baskets of shrimp, one hand peeled, the other machine peeled, were canned after a total of 5 days' storage, and the last two were canned after 7 days' storage. At this point the whole shrimp were still considered to be of satisfactory commercial quality.

At each packing interval the shrimp after being either hand or machine peeled were blanched 3 to 5 minutes in 50° salinometer brine, sorted according to size and hand packed 5 ounces of meat per 211 x 300 can. The can was then filled with hot 180° F.-190° F. 2% brine (approx. 17 lbs. salt/100 gal. water), sealed, processed for 12 minutes at 250° F. and water cooled. Standard commercial shrimp cans, inside enameled throughout, were used for all packs. Twenty-four cans of each size shrimp (pieces, small, medium, and medium-mixture) both hand and machine peeled were canned at each of the 3 packing intervals. In addition, 24 cans of medium sized white shrimp were canned with citric acid brine at each packing interval.

Three cans of each variable packed were examined initially and after 1, 6, and 12 months' storage at 98° F.

Experimental pack of sea-bobs. This pack was made with one lot of sea-bobs which had been iced aboard a commercial shrimp boat for from one to two days prior to receipt at the cannery. One-half of the lot was machine peeled, blanched, and canned immediately upon receipt; the remainder after having been iced for an additional three days. Twenty-four cans of each variable packed were examined after 3 months' storage at room temperature.

RESULTS AND DISCUSSION

Results of the examination of the packs of common white shrimp which were iced for 1, 5 and 7 days prior to packing are given in Table 1.

Based on the data reported in Table 1, it may be seen that:

As the length of storage in ice prior to canning increased both the product pH and the amount of graying increased in wet pack shrimp. These increases occurred regardless of shrimp size or method of peeling. (Figures 1 and 3).

The severity of product graying increased as the size of the shrimp canned decreased. (Figure 1).

With fresh shrimp, little if any difference in product graying could be noted between canned white shrimp which were either hand or machine peeled. However, in the lot of white shrimp studied, slightly more product graying occurred in machine peeled than in hand peeled shrimp which were iced for 5 or more days prior to canning. (Figure 2).

Container discoloration occurred in only 10 of the 288 cans examined. Although the incidence was very low and the discoloration not sufficiently severe to be com-

[a] Presented at the 16th Annual Meeting of the Institute of Food Technologists, St. Louis, June 11, 1956.

[b] The "brasilian" shrimp actually include three species of shrimp *Penaeus aztecus, P. Duorarum,* and *P. brasiliensis (2).*

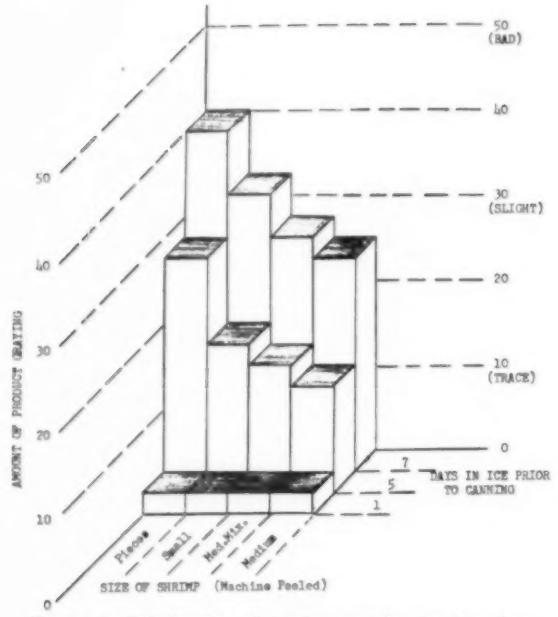

Figure 1. Relationship of product graying to size of common white shrimp.

mercially objectionable, it is interesting to note that no discoloration occurred with "fresh" (iced one day) shrimp.

It should be remembered that the shrimp used in this experiment were iced under ideal conditions and as a result no severe graying or container discoloration occurred.

The results of examinations of medium sized white shrimp which were iced for 1, 5 and 7 days prior to

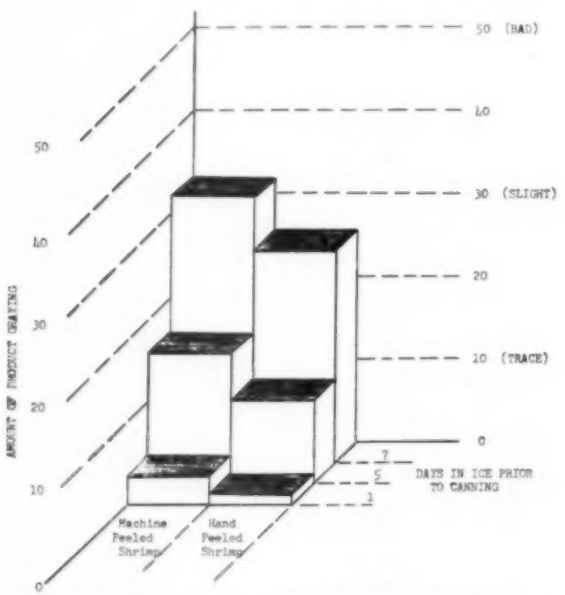

Figure 2. Relationship of product graying to method of peeling white shrimp.

packing with citric acid brine are compared with the results obtained with untreated samples in Table 2.

Based on the data reported in Table 2 it may be seen that:

Citric acid brine added at a pH of 3.0 or 4.6 to the shrimp (finished product pH 6.6 or 6.5) (Table 2), slightly improved the appearance, flavor and texture of the product; the most noticeable effect, as measured organoleptically, being an improvement in texture of the finished product. At these levels the citric acid brine

TABLE 1

pH, product graying and container discoloration noted in samples of common white shrimp of varying size held in ice 1, 5 and 7 days prior to canning

Size	Days in ice prior to canning	Average[1] pH	Product graying		Container discoloration[3]
			Range	Average[2]	
Hand Peeled					
Pieces	1	6.7	0	0	0
Pieces	5	7.0	tr	10	0
Pieces	7	7.1	vsl – mod	28	0
Small	1	6.7	0	0	0
Small	5	6.9	tr	12	0
Small	7	7.0	tr – vsl	20	trace – 2 cans
Medium	1	6.7	0	0	0
Medium	5	6.9	tr	8	trace – 1 can
Medium	7	7.0	sl	20	trace – 1 can
Medium Mixture	1	6.7	0 – tr	3	0
Medium Mixture	5	6.9	tr – vsl	13	0
Medium Mixture	7	7.0	tr – mod	25	0
Machine Peeled					
Pieces	1	6.8	0 – tr	3	0
Pieces	5	7.0	vsl – sl	27	trace – 1 can
Pieces	7	7.0	mod	40	vsl – 1 can
Small	1	6.7	0 – tr	3	0
Small	5	6.9	tr – vsl	18	0
Small	7	7.0	sl – mod	33	tr – 1 can
Medium	1	6.7	0 – tr	3	0
Medium	5	6.9	tr – vsl	13	tr – 1 can
Medium	7	7.0	tr – mod	25	0
Medium Mixture	1	6.7	0 – tr	3	0
Medium Mixture	5	6.9	tr – vsl	15	tr – 1 can
Medium Mixture	7	7.0	vsl – sl	28	tr – 1 can

[1] Three cans of each variable were examined initially and after 1, 6 and 12 months' storage at 98° F. Since the pH of the shrimp meats and brine equalized in approximately one week following processing, the pH measurements reported here were taken on the free-liquor from the cans. The data represent averages of the results of the four examinations. No significant change in pH of any variable was noted during the one year storage period.

[2] Arbitrary values were assigned to amounts of graying as follows: None—0; trace—10; very slight—20; slight—30; moderate—40; bad—50. The average amount of graying noted at each of the four examinations was assigned a value and the four values averaged. Trace amounts of graying would not be considered objectionable commercially.

[3] None of the discoloration noted with these samples would be considered commercially objectionable. The black iron sulfide discoloration noted in these packs occurred on the surface of the inside enamel of the top end.

had no appreciable effect on the formation of product graying.

The amount of product graying was decreased by adding citric acid brine at a pH of 2.2 (finished canned product pH — 5.6) to shrimp which were well iced for seven days prior to canning; however, the flavor and texture of the finished product was impaired. The most noticeable effect was on the texture of the shrimp which became overly tough.

Only three concentrations of citric acid brine were used in this experiment. It is probable, based on the

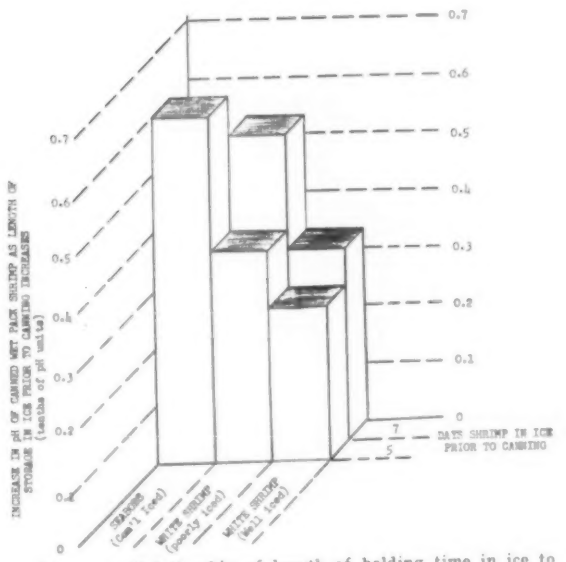

Figure 3. Relationship of length of holding time in ice to increase in product pH.

limited data reported here, that the best effects, i.e., an improvement in appearance, flavor and texture of the product, and a decrease in graying, would be obtained by reducing the finished product pH to 6.0 — 6.4 with citric acid brine.

TABLE 2

pH, organoleptic rating and product graying noted in samples of medium sized white shrimp packed with untreated and citric acid treated brine

pH added brine[1]	Days shrimp in ice prior to canning	Organoleptic score[2]	Average[3] product pH	Amount of product graying[4]
Hand Peeled				
4.6	1	60	6.6	3
7.9 (untreated)	1	55	6.7	0
3.0	5	55	6.5	11
7.9 (untreated)	5	50	6.9	8
2.2	7	40	5.6	3
7.9 (untreated)	7	50	7.0	20
Machine Peeled				
4.6	1	60	6.6	3
7.9 (untreated)	1	55	6.7	3
3.0	5	55	6.5	10
7.9 (untreated)	5	50	6.9	13
2.2	7	40	5.6	5
7.9 (untreated)	7	50	7.0	25

[1] Citric acid was added to the canners normal (untreated) 2% brine (pH — 7.9) to obtain the pH listed. The amount of citric acid added to the brine was increased at each packing interval as the age of the shrimp in ice increased.

[2] The organoleptic scores given above were obtained by weighing the appearance, flavor and texture of the product equally and considering the scores as follows: 30-35 poor; 40-45 fair; 50-55 average; 60-65 good; etc. The organoleptic scores are based on the condition of the shrimp after being canned for 1 month.

[3] Three cans of each variable were examined initially and after 1, 6 and 12 months' storage at 98° F. The data reported are averages of the results of the four examinations.

[4] Arbitrary values were assigned to amounts of graying as follows: none—0; trace—10; very slight—20; slight—30; moderate—40; bad—50. The average amount of graying noted at each of the four examinations was assigned a value and then averaged.

The results of examinations of experimental packs of seabobs iced for 2 and 5 days prior to canning are given in Table 3.

Data in Table 3 show that as the length of storage in ice prior to canning increased from 2 to 5 days, the

TABLE 3

pH, product graying, and container discoloration noted in samples of canned machine peeled sea-bobs which were iced 2 and 5 days prior to packing

Days in ice prior to canning[1]	Average[2] product pH	Average[2] product graying	Container discoloration[2]
2	7.0	0	None
5	7.6	40[3]	16 cans

[1] The lot of sea-bobs used in this pack were "fresh" (1 to 2 days old) when purchased. Half of the lot was canned immediately; the remainder after being iced for an additional 3 days.

[2] Twenty-four cans of each variable were examined after 3 months' storage at room temperature.

[3] Moderate amounts of graying were noted in all samples of this variable. See footnote 4, Table 2.

product pH, product graying, and container discoloration increased markedly. This substantiates the findings reported earlier with common white shrimp; however, the increases noted with sea-bobs were more rapid (Figure 3). One reason for this is the smaller size of sea-bobs as compared with common white shrimp.

In addition to the experimental packs, numerous commercial samples of wet pack shrimp were also examined. The results of the examination of one of these samples is of particular interest since it shows the effect of poor icing conditions on common white shrimp held up to 7 days prior to canning. The shrimp were in excellent condition when received at the cannery after having been iced aboard a commercial shrimp boat for 2 days. Part of the lot was canned immediately; the remainder were iced in wooden boxes stored in an open room for an additional 5 days. The pH of the products prepared using these shrimp increased from 6.8 to 7.5 (Figure 3) and the amount of product graying from none to bad as compared to a maximum increase in pH of from 6.7 to 7.1 (average 6.8 to 7.0) with well-iced white shrimp held the same number of days in ice prior to canning. These changes in pH of the canned product are just one measure of the actual condition of the shrimp when packed and indicate that probably the most important factor influencing the formation of product graying in wet pack shrimp is the actual condition of the shrimp packed.

SUMMARY AND CONCLUSIONS

The work reported here was conducted in an attempt to determine the factors influencing the formation of product graying and/or container discoloration noted in commercially canned wet pack shrimp.

Based on the results of this work the following conclusions may be drawn:

As the age of shrimp in ice prior to canning increased there was a measurable increase in the pH of the canned product. (Figure 3). The increase in pH occurred prior to spoilage, i.e., while the shrimp were still considered visually to be of satisfactory commercial quality.

As the pH of canned wet pack shrimp increased the amount of product graying and/or container discoloration which occurred in the canned product also increased.

As the size of the shrimp packed decreased the severity of product graying which occurred in the canned product increased. (Figure 1).

The method of peeling fresh shrimp either by hand or machine, had little effect on product graying.

The use of citric acid brine to reduce the pH of canned wet pack shrimp will have to be studied further to determine the exact reduction necessary to obtain the best effects on the product. Based on the limited data obtained here, it is probable that the best effects, i.e., an improvement in the appearance, flavor and texture of the canned product and a reduction of graying, would be obtained by reducing the finished product pH to 6.0 to 6.4 with citric acid brine.

As might be expected, shrimp condition or quality at the time of packing is the most important single factor involved in the occurrence of product graying and/or container discoloration in canned wet pack shrimp.

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Effects of Packing Procedure on Container Performance in Canned Applesauce[a]

G. G. Kohn and J. E. Fix
Research and Technical Department, American Can Company, Newark, New Jersey

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Throughout its history, canned applesauce in metal containers has frequently exhibited headspace corrosion, marked by discoloration of the product and localized severe detinning of the container. Records show that more than 20 years ago when only hot dipped tinplate was used canners were aware of the gray color which occasionally occurred in the headspace area of canned sauce and the severe etching of the container in the same area. This undesirable condition was and still is most prevalent in the No. 10 and No. 2 can sizes and those who analyzed the facts could not but associate these occurrences with the relatively large headspaces commonly used with these can sizes. Normally the commonly used label weight declaration of 6 lb. 12 oz. for No. 10 applesauce cans produces headspaces so large that it is not unusual for packers of this product to fill from one to four ounces over the declared weight. A similar situation occurs with the customary 20 oz. label weight declaration in No. 2 cans.

With the advent of electrolytically coated tinplate and the recognized desirability of tin conservation measures, the tin coating weights used for metal food containers have been reduced throughout the canning industry. The containers used for applesauce were not excepted from these economic pressures and the use of cans made wholly or in part of plain inside No. 100 or No. 100/25 differentially coated electrolytic tinplate has become standard for this product.

During the change-over period, while electrolytic tinplate was becoming more widely used for applesauce, the occurrence of objectionable headspace detinning and product discoloration became associated in the minds of some observers with the introduction of electrolytic plate. As is herein shown, this impression was primarily due to the change in character of the discoloration of the tinplate. Since the use of electrolytic tinplate was desirable both from an economic and a tin conservation standpoint, it was felt that the facts regarding this condition should be investigated with the ultimate goal of devising means of avoiding this difficulty. In the Fall of 1955, the American Can Company Research and Technical Department, with the cooperation of the C. H. Musselman Company, undertook a rather extensive controlled test pack, made under commercial conditions. The projected storage period of this pack has not been completed but the results of the six-month storage examination have been so clear cut and important to the applesauce canning industry that it was considered desirable to make the information generally available at once.

MATERIALS AND METHODS

The test pack was designed to study the effect of 7 different can variables and 6 different fill and closure variables on the headspace detinning and product discoloration of canned applesauce.

Applesauce. The applesauce was made from a commercial blend of apples employing the customary procedure used by the packer. This procedure consisted of blending the different apple varieties and washing, sorting, size grading, peeling, coring and trimming the apples. The peeled apples were then chopped and cooked in a continuous type cooker by injection of live steam. A predetermined amount of granular sugar was metered into the cooker near the feed end. The applesauce was then passed through a paddle type finisher. Finally, the sauce was pumped to a piston type rotary filler and filled into cans or glass jars at a minimum temperature of 195° F. Following a suitable holding period, the containers were water cooled to an average temperature of 100° F. Inasmuch as previous experience has shown that headspace detinning occurs in applesauce made from any blend of apples, canned at any time during the year and packed in any part of the country, the test pack was limited to sauce made from Virginia grown apples harvested at the beginning of the canning season. This applesauce had the following chemical characteristics: moisture 79.0%, soluble solids 19.7% (as sucrose), total acidity 0.40% (as malic acid), pH value 3.2, sodium chloride 0.14% (as total chloride).

[a] Presented before the Sixteenth Annual Meeting of the Institute of Food Technologists, St. Louis, Missouri, June 11, 1956.

TABLE 1
Container variables

Container code	Can body			Can ends		
	Tin plate	Base steel	Enamel	Tin plate	Base steel	Enamel
1	Comm. Cokes	MR	Plain	No. 25	MR	Sanitary
2	Comm. Cokes	L	Plain	No. 25	MR	Sanitary
3	Std. Cokes	L	Plain	No. 25	MR	Sanitary
4	No. 100/25	MR	Plain	No. 25	MR	Sanitary
5	No. 100/25	L	Plain	No. 25	MR	Sanitary
6	Comm. Cokes	MR	Plain	Comm. Cokes	MR	Plain
7	No. 100/25	L	Sanitary	No. 100/25	L	Sanitary
8	15 oz. glass jar			58 mm. inside enameled cap		

Container variables. The different container variables used for the test pack are listed in Table 1. All cans were of the 303 x 406 size. They were of standard construction manufactured by the American Can Company from either hot dipped or electrolytic, type L or type MR tinplate and on the inside were either plain or lined with sanitary enamel. The 303 x 406 can size was selected in preference to larger size cans because of the practical necessity to limit the amount of applesauce packed and because of the availability of commercially operating equipment for this size can. The hot dipped tinplates included in this test were Common Cokes which have a nominal tin coating weight of 1.25 pound per base box, and Standard Cokes with a nominal tin coating weight of 1.50 pounds per base box. The electrolytic tinplates used were No. 25 which has a nominal tin coating weight of 0.25 pounds per base box and differentially coated No. 100/25 plate which on one side of the sheet has a nominal tin coating weight of 1.00 pound of tin per base box and on the other side has a nominal tin coating weight of 0.25 pound of tin per base box. With No. 100/25 plate the heavier tin coating was on the inside of the can. Type L tinplate designates a highly corrosion resistant base steel which has a lower phosphorous and copper content than the type MR tinplate. Sanitary enamel is an oleoresinous type enamel generally used for fruit or acid food products. The glass jars used as controls were made from flint light weight glass and had an overflow capacity of 14⅝ fluid ounces. The glass jars were closed with an inside enameled 58 mm. cap supplied for the packer's commercial operation.

Fill and closure variables. All can variables were filled with three different fill-in weights of applesauce. These averaged 18.1 ozs., resulting in a full can; 17.4 ozs., resulting in the customary headspace normally attained under commercial packing conditions in 303 x 406 size cans; and 16.5 ozs., resulting in excessively large headspaces. All cans were closed with either standard hermetic closure or steam flow closure. The latter type of closure consisted of a regulated flow of steam flushing out the headspace air as the cover was assembled on the can. A summary of the fill and closure variables of the cans is presented in Table 2. All glass jars were filled and closed with the normal commercial procedure used by the cooperating packer.

TABLE 2
Can fill and closure variables

Container code	Fill variable	Closure Variable
FH	Full Can	Standard Hermetic Closure
NH	Normal Headspace	Standard Hermetic Closure
NS	Normal Headspace	Steam Flow Closure
LH	Large Headspace	Standard Hermetic Closure
LS	Large Headspace	Steam Flow Closure

Container handling. All container, fill and closure variables were packed consecutively and intermixed in a minimum amount of time so as to insure uniform conditions in regard to applesauce, filling, cooling temperatures, etc. The cans were closed at a speed of approximately 270 cans per minute on a Canco 401-4RS steam flow closing machine with the steam turned off or on according to whether standard or steam flow closure was required. The closed cans were immediately inverted, held on a cable conveyor for three minutes, and water cooled with the bottom ends up in a Draper type cooler to an average temperature of 100° F. The cold cans were cased on commercial equipment and stacked with the bottom end down for 2 to 4 hours. After this time, the cans were sorted by code, recased and stored with the bottom ends up again. The cans remained in the latter position for all subsequent storage. For the first 2 weeks, they remained undisturbed at the cannery in order to allow for any initial reaction to reach equilibrium. The cases were then shipped to the Atlantic Division Laboratory of the American Can Company in Newark, N. J., where they were sorted into room temperature and 98° F. storage. The glass jars were closed, inverted and water cooled on commercial equipment.

Examinations. An initial examination of the containers and product was made 4 days after packing, and periodic examinations were scheduled every 3 to 6 months over a 2-year period. Four samples of each variable from each storage temperature were opened at each cutting. The examinations included collection of physical data such as net weight, gross headspace and vacuum; visual observation on container corrosion and product color; and organoleptic examination of the applesauce.

The gross headspaces were taken after dispersing uniformly the product level by measuring the distance from the top of the doubleseam to the product level by means of Starret depth gauge.

The vacuums were measured with a standard puncture vacuum gauge. No compensation for the air content of the Bourdon tube of the vacuum gauge was made.

RESULTS

The results of the 6 months' storage examination are listed below:

Net weight, headspace and vacuum. The net weight, gross headspace and vacuum measurements are summarized in Table 3. There was no significant difference in the vacuum of different

TABLE 3
Summary of net weight, headspace and vacuum measurements in 303 x 406 cans of applesauce stored for six months at room temperature

Fill and closure variables		No. of cans examined	Net weight (ozs.)		Gross hdspce. (32nd in.)		Vacuum (in.)	
Headspace	Closure		Range	Av.	Range	Av.	Range	Av.
Small	Standard	44	17.7-18.3	18.1	8-12	9	15-21	19
Normal	Standard	44	16.8-17.8	17.4	10-15	12	18-21	20
Normal	Steam Flow	44	16.3-17.9	17.4	9-14	12	19-26	23
Large	Standard	44	16.1-17.1	16.5	17-23	20	15-18	17
Large	Steam Flow	44	15.9-16.9	16.4	17-23	20	25-27	26

can variables packed under the same conditions of fill and closure. At the time of the six months' examination, there was no significant change in vacuum since the initial examination in cans stored at either room temperature or at 98° F.

Can corrosion. The following visual observations were made with regard to can corrosion on cans stored at room temperature. The same general observations were made on cans stored at 98° F. with the conditions described below being slightly more pronounced.

(a) All can variables filled full or to a normal headspace and closed under either standard hermetic or steam flow closure, as well as all can variables filled to a large headspace and closed

with steam flow closure showed practically no detinning in the headspace area of plain can bodies. All can variables filled to a large headspace and closed with standard hermetic closure exhibited severe detinning in the headspace area of plain can bodies.

(b) The detinned headspace areas appeared very dark in the electrolytic No. 100/25 and greyish in the hot dipped bodies.

(c) The headspace detinning occurred at spots which apparently had remained in contact with applesauce during storage and at the interfacial area which outlines the product level. The remaining portions of the headspace were not attacked.

(d) Slight etching was observed on all plain tin bodies and plain tin ends below the product level. This condition was more noticeable in the electrolytic No. 100/25 tin plate than in the hot dipped tin plate because of the particular etching pattern of the former. Some detinning of the plain differentially coated No. 100/25 can bodies below the product level was noticeable in cans stored at 98° F. It was considerably more pronounced in cans filled to a large headspace and closed under standard hermetic closure than in the other fill and closure variables.

(e) The fully plain cans showed slightly less detinning in the body headspace area than equivalent cans with enameled ends, however, the over-all body etching was equal in both can variables. Cans with plain ends exhibited some detinning of the headspace end which resulted in an undesirable appearance from a consumer point of view.

(f) The fully enameled cans showed some underfilm corrosion and slight loss of enamel adhesion in the body headspace area and on the headspace end. Corrosion was also observed at the side seam fold and at points of enamel scratches in these cans. Again, these conditions were more pronounced in the large headspace cans given a standard hermetic closure than in the other variables.

(g) In general, there was no significant difference in performance between the type L or type MR steel base with either hot dipped or differentially coated electrolytic tinplate.

Product color. The color of the applesauce in all cans and glass jars stored at 98° F. was considerably darker than the corresponding samples stored at room temperature. The applesauce in the fully enameled cans had a pink cast and was darker than the product in fully plain or plain bodied cans. The color was similar to that of the applesauce packed in glass jars. The color difference in the above container variables was more noticeable in the 98° F. storage samples than in the room temperature storage samples, and in the large headspace standard hermetically closed samples than in the other fill and closure variables. The product darkening in the fully enameled cans was more pronounced before removing the product from the cans due to light reflection from the enameled bodies.

In general, there was no significant difference in the color of the applesauce from steam flow closed cans as compared to standard hermetically closed cans.

Product flavor. There was a very slight difference in flavor between the applesauce from the fully enameled cans and the product from the plain cans. Both flavors, however, were satisfactory.

There was no difference in the flavor of applesauce packed in steam flow closed cans from that packed in standard hermetically closed cans.

DISCUSSION

The results of the test pack showed that excessive air in the headspace of canned applesauce can result in severe localized detinning in either electrolytic or hot dipped tinplate. The detinning is undesirable mainly from an appearance standpoint and generally does not affect the product. In severe instances, however, product discoloration in the headspace area can occur. The results further showed that the severe localized headspace detinning can be virtually eliminated by removing the excessive headspace air at closure. This can be accomplished in two ways: filling the can full, or using a method of closure which will remove the headspace air. There are advantages and disadvantages to each method.

These are:

Fill increases. *Advantages.* This method does not require changes in either procedure or equipment except for increasing the fill-in volume in some can sizes. The can vacuums remain unchanged from those attained with the customary packing procedure.

Disadvantages. Increasing the fill-in weight would probably not result in a corresponding shelf price increase unless an industry agreement is reached to increase the label weight declaration and to charge the additional product to the consumer. If filling operations cannot be carefully controlled, spillage at filling and closure will occur. It may be difficult to fill cans consistently with the increased weight due to changes in specific gravity of the applesauce throughout the canning season. Complete filling of cans, particularly the No. 10 size, may lead to cooling difficulties where agitated can cooling methods are used.

Low oxygen closure. This method would include steam flow, gas flow or vacuum closure.

Advantages. The presently used filling practices, label weight declarations and can sizes remain unchanged.

Disadvantages. An initial investment in special closing equipment will be needed. Steam flow or vacuum closure would increase the container vacuums to a point where paneling may become a problem. Consequently, stronger containers may be required which would be more expensive; gas flow closure would require the additional expense of the inert gas. Although insufficient commercial experience with steam flow closure for canned applesauce is available as yet to evaluate it thoroughly, this closure method seems to be the most suitable immediate solution for the problem.

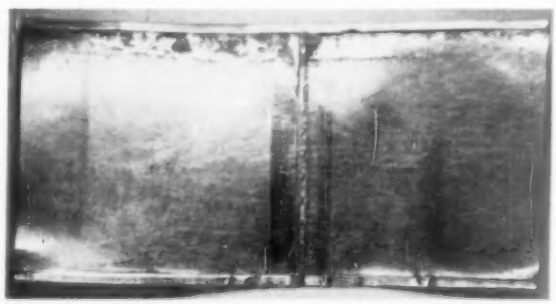

Figure 1. 303 x 406 can of applesauce packed with a large headspace and sealed with standard hermetic closure showing detinning in the headspace area of the plain Common Cokes body after six months' storage at room temperature.

Changes in container sizes to reduce the headspace and still conform to present label weight declarations are not considered acceptable solutions since they are contrary to the aims of the "Simplified Practices Recommendations F 155-49" promulgated on June 1, 1949, by the Commodity Standards Division, National Bureau

of Standards, U. S. Department of Commerce. Such changes are undesirable from the standpoint of both manufacturer's and supplier's inventory. The use of non-standard size containers could increase container costs to the packer. An industry-wide agreement would probably have to be reached in order to provide broker and consumer acceptance of can height changes. Difficulties such as cooling of large size cans, spillage and attaining consistently the minimum fill-in weight as outlined for the "fill increase" method would be encountered with the can height reduction also.

The headspace detinning problem exists primarily with the larger can sizes such as the No. 2 or the No. 10. These cans customarily have label weight declarations of 20 ozs. and 6 lbs. 12 ozs. respectively which result in excessively large headspaces. Smaller cans

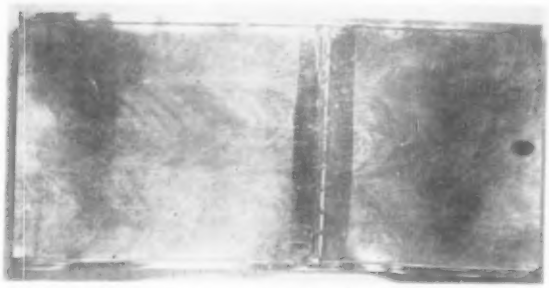

Figure 2. 303 x 406 can of applesauce packed with a large headspace and sealed with steam flow closure showing no detinning in the headspace area of the plain Common Cokes body after six months' storage at room temperature.

such as the 211 x 304 and the 303 x 406 sizes have more realistic label weight declarations resulting in headspaces which apparently are satisfactory. In general, little or no problem of headspace detinning is encountered with the latter sizes.

A plain tin surface exerts a beneficial bleaching action on applesauce. Thus, in order to produce a light colored, attractive looking applesauce, it is necessary to use cans made wholly or in part with an inside plain tin surface. Applesauce packed in fully inside enameled cans becomes darker than comparable sauce packed in plain bodied cans. Cans made from plain tinplate throughout may occasionally exhibit some detinning on the headspace end which would detract from their appearance. As mentioned previously, both hot dipped and electrolytic tinplates are affected by the headspace detinning. The detinned portion in the electrolytic tinplate appears darker than in the hot dipped tinplate. Explanation of this fact lies probably in the larger tin alloy layer of the hot dipped tinplate which provides a grayish appearance after removal of the free tin layer whereas the bare steel base becomes more readily visible in the case of electrolytic tinplate. In any event, if the headspace air has been reduced sufficiently by any of the methods discussed above, cans made from either plain electrolytic No. 100, No. 100/25 or plain hot dipped Common Cokes bodies with inside enameled electrolytic ends should be satisfactory for canned applesauce.

High temperature storage adversely affects the color and flavor of canned applesauce and increases the degree and rate of corrosion.

SUMMARY AND CONCLUSIONS

Localized headspace detinning is a problem primarily in the larger cans of applesauce. It is undesirable mainly from the appearance standpoint. It occurs both on electrolytic and hot dipped tinplate, although due to a darker appearance it may be more noticeable in the former. In severe instances, the product adjacent to the detinned areas may become discolored. An extensive controlled test pack made under commercial packing conditions revealed that the detinning is associated with excessive amounts of air in the headspace. It can be controlled by reducing the headspace to a minimum at closure or by using a method of closure which will largely remove the headspace air.

The type of cans presently used for applesauce made from plain either electrolytic or hot dipped bodies and inside enameled electrolytic ends give satisfactory results if excessive amounts of headspace air are eliminated. Fully enameled cans are unsatisfactory because of a general product darkening. Inside plain ends may show some unattractive detinning. The storage tests will be continued further to determine if any changes occur with time which would alter the above observations. Additional work may be dictated by the final results.

A Rapid Vacuum Distillation Procedure for The Determination of Volatile Acids and Volatile Bases in Fish Flesh[a]

Tetuo Tomiyama,[b,c]
Antonio A. da Costa,[d,e]
and Joseph A. Stern
School of Fisheries, University of Washington, Seattle, Washington

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THE CHEMICAL INDEX accepted as standard for use in estimating the freshness or quality of fish differs in different countries. In the United States, the Volatile Acid Number is widely used and an official method, utilizing a steam distillation procedure for the determination of this index, has been published *(1)*. In Japan, the Volatile Basic Nitrogen Content is used almost exclusively as the chemical index for estimating the quality of all species of fish (except shark), and an official method, utilizing either a vacuum distillation procedure or an alternative aeration procedure, has been published there *(6)*.

The official methods for both these chemical indices are time consuming. They require lengthy and somewhat complicated preparations of samples and prolonged distillations or aerations, the rates of which must be carefully controlled. As a result, only a very few determinations can be run with a single apparatus or by one person during a working day.

Other non-official methods for the determination of the Volatile Acid Number *(4, 7)* and the Volatile Bases Content *(2, 3, 8)* have been used but most of them are little better than the official methods from the standpoint of time consumption.

Since the determinations of these chemical indices are routinely used in investigations where large numbers of determinations must be made, it is desirable to have a procedure for either or both of the chemical indices that is rapid and yet sacrifices neither the accuracy nor precision of the official methods. In 1952, Tomiyama and Harada *(9)* partly achieved this goal by modifying the vacuum distillation procedure for the determination of the Volatile Bases Content, as used officially in Japan, and by developing a procedure that shortened the time necessary for a determination of this index.

The present paper presents a further modification of the vacuum distillation procedure that makes it suitable for determinations of both the Volatile Acid Number and the Volatile Bases Content.

The primary advantages of the method are the rapidity with which the determinations can be run and the extremely short time and simple operation used for cleaning the apparatus between determinations. In addition, a single, stable extract of flesh is prepared and used for both determinations.

METHODS

Preparation of sample. A representative sample of flesh is taken and passed through a grinder three times. Eighty-five grams of the comminuted flesh are added to 200 ml. of water in a blender-top and the mixture homogenized for 3 minutes. Four hundred ml. of a $MgSO_4$-solution are added to 200 g. of the homogenate in a large flask. The mixture is shaken well and then filtered through Reeve Angel No. 235 filter paper.[f] The resulting filtrate should be clear and at a pH of 2.0. It is recommended that the pH of the filtrate be determined on a pH meter and adjusted to pH 2 before proceeding further. Fifty ml. of the filtrate are equivalent to 5.0 g. of flesh.

The $MgSO_4$-solution is prepared by dissolving 600 g. of $MgSO_4$ in distilled water and making the solution to a volume of 1L. with additional distilled water. Then, 20 ml. of 6N H_2SO_4 are added to the solution.

Description of apparatus. A photograph of the apparatus is presented as Figure 1. An isometric drawing of the apparatus is presented as Figure 2 for illustrative purposes.

The apparatus utilizes a 500 ml. round bottom three-neck flask as the distillation vessel (A). A tube passes through the stopper in the left neck of the flask and is connected to a small funnel (B) by a wide bore stopcock (X). Another tube (C) leads from the bottom of the flask through the stopper in the right neck of the flask to a waste trap (V) with a connecting stopcock (Y). The waste trap is connected by a stopcock (U) to the vacuum system, which, in our laboratory, is an aspirator pump (D).

A modified Claisen-type distilling tube (E), of almost equal diameter as the central neck of the distilling flask, extends a short way into the flask beneath the stopper in the central neck. The vertical neck of the tube extends only one-half inch above the joint of the side neck of the tube. The mouth of the vertical neck is stoppered. Passing through this stopper, a capillary tube (F) extends to the bottom of the flask. The purpose of the capillary is for the admittance of air, as an agitating agent, during the distillation.

The side neck of the Claisen-type tube extends only an inch above the joint of the side arm leading to the cooling system. The mouth of the side neck is stoppered. Passing through the stopper is a small bent tube (G), the tip of which projects into the side arm of the Claisen-type distilling tube. A small funnel (H) is attached to the other end of this tube by a short piece of rubber tubing, and a pinchcock.

The side arm of the Claisen-type tube enters the cooling system through a two-holed stopper in the mouth of a 300 mm. Liebig condenser (I). A thermometer (J) is placed in the second hole of the stopper with the bulb extending approximately one-half inch below the stopper.

The adapter tip of the condenser (I) is bent in a vertical plane to an approximate right angle with the body of the condenser. A second 300 mm. Liebig condenser (K) is modified by drawing the mouth into a bent tube and by bending the adapter tip. The adapter ends of the two condensers are connected by a short piece of rubber tubing in such a manner that the second condenser (K) is approximately at right angles to the first condenser (I) in an approximately horizontal plane.

The tubular mouth of the second condenser (K) is attached by a short piece of rubber tubing to the bubbling tube. The

[a] Contribution No. 15, School of Fisheries, University of Washington, Seattle.

[b] Fulbright Lecturer, School of Fisheries, University of Washington, 1955-1956.

[c] Chairman, Department of Fisheries Chemistry, Kyushu University, Fukuoka, Japan.

[d] Recipient of a National Academy of Science grant as a part of Project No. TA 01-101-3006 (OEEC-151) of the U. S. International Cooperation Administration.

[e] Chief Engineer, Industrial Services, Instituto Portugues de Conservas de Peixe (Portuguese Institute of Canned Fish), Lisbon, Portugal.

[f] Any long fibered filter paper with great wet strength and high filtering speed can be used.

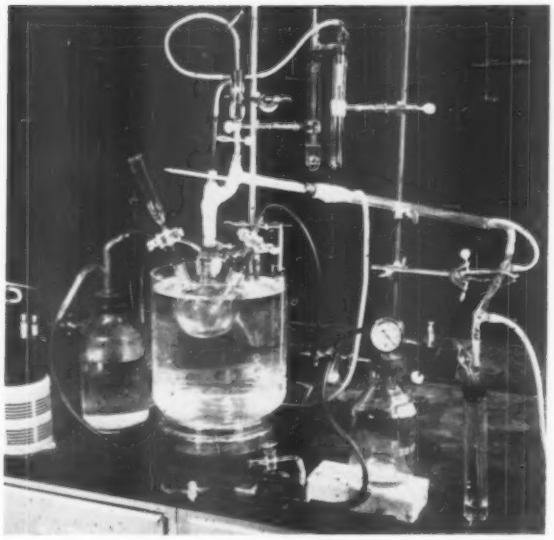

Figure 1. Photograph of the vacuum distillation apparatus.

bubbling tube passes through one hole of a two-holed rubber stopper in the mouth of a 38 x 200 mm. test tube which serves as a receiving vessel (L), and extends below the surface of the trapping liquid in the receiving vessel. A celluloid disc rides on the bubbling tube. The purpose of the disc is to prevent escape of the trapping fluid from the receiving vessel by breaking up large bubbles which may develop during the distillation or when the vacuum in the system is released.

A tube with a bulbular flash-trap passes through the second hole of the rubber stopper in the mouth of the receiving vessel and extends only a short distance into the vessel itself. This tube is connected to a trap-bottle (M) by rubber tubing and a screw-type pinchcock (Z). The trap-bottle, which has a vacuum gauge attachment (N), is connected to the vacuum system. An air inlet tube, controlled by a stopcock (O), is placed in the vacuum line for maintenance of the proper pressure in the system.

All air drawn into the apparatus during and following the distillation is first bubbled through an NaOH solution (W) to remove CO_2.

A controlled, constantly agitated water bath (P) is used as the source of heat for the distillation. The distillation vessel (A) is immersed in the bath to the necks of the flask. Both necks and the side arm of the Claisen-type distilling tube, as well as the mouth of the first condenser (I), are insulated to prevent premature condensation of the distillate.

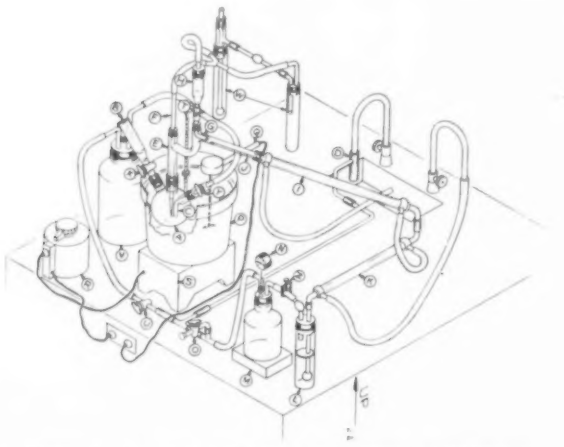

Figure 2. Isometric drawing of the vacuum distillation apparatus. Descriptive lettering is explained in the text.

Procedure. The stopcock (U) and (Y), and the screw pinchcock (Z) are closed. The aspirator pump (D) is turned on and the vacuum is adjusted to 29 inches of Hg. by regulating the stopcock (O). A receiving vessel (L) is prepared and attached to the system. If the Volatile Acid Number is to be determined 10 ml. of 0.01 *N* NaOH are placed in the receiving vessel; if the Volatile Bases Content is to be determined 10 ml. of *N*/28 H_2SO_4 are placed in the receiving vessel.

The stopcock (X) is opened and 50 ml. of the sample solution are added to the distilling flask (A) via the funnel (B). If the determination is of the Volatile Acid Number the distillation is then begun; if the determination is of the Volatile Bases Content, 5 ml. of a 10% NaOH solution are added to the flask (A).

The distillation is started by closing stopcock (X) and slowly opening the screw pinchcock (Z), thus permitting a vacuum to be drawn in the system. As the distillation begins the temperature, as shown by the thermometer (J) in the mouth of the first condenser (I), rises rapidly. As the distillation continues, the temperature slowly falls. When the temperature reaches a steady state 3 or 4 degrees Centigrade above room temperature, the distillation is completed.

If the determination is that of bases, the distillation procedure is at an end. If the determination is that of acids, 20 ml. of distilled water are added to the distillation vessel without breaking the vacuum by means of the funnel (B). The distillation is permitted to continue until the temperature, as shown by the thermometer (J), has again reached a steady state a few degrees above room temperature.

Following the distillation procedure, the screw pinchcock (Z) is closed and 20 ml. of distilled water are flashed into the apparatus through the funnel (H) and bent tube (G) assembly of the side neck of the Claisen-type tube. This water washes the cooling system and is collected in the receiving vessel. The vacuum is then released by allowing air to enter the system through this same assembly.

When the vacuum has been dissipated, the receiving vessel (L) is disconnected and removed from the apparatus, and the trapping liquid is titrated with either standard acid or standard base, depending upon the determination. The titration is carried out in the receiving vessel itself, using the bubbling tube as a stirring rod. In the determination of the Volatile Acid Number neutral red[g] is used as the indicator; in the determination of the Volatile Bases Content, methyl red is used.

Water is then run into the distillation vessel (A) through the funnel (B) until the flask is full. Stopcock (X) is closed, and stopcocks (U) and (Y) are opened. The water in the flask is sucked through the tubular system into the waste trap (V). This operation is repeated at least twice or until the flask is clean. The condenser system (I, K) and the Claisen-type distilling tube are thoroughly washed by immersing the receiving vessel tip of the second condenser (K) in water while the syphoning operation is in progress. The entire washing procedure requires about two minutes.

The temperature of the water bath is maintained throughout the distillation and washing procedures at 75° C. The vacuum is maintained at a constant 29 inches of Hg.

The distillation procedure for the determination of the Volatile Bases Content requires about 5 minutes; the distillation procedure for the detrmination of the Volatile Acid Number requires a total of about 10 minutes for the completion of both the primary and secondary distillations.

EXPERIMENTAL RESULTS

A series of experiments were performed to determine the rates of distillation and recovery of pure acids under the conditions of temperature and vacuum used in the procedure. One part of a 0.005 *N* solution of either acetic or formic acid was

[g] Neutral red was chosen as the indicator, for phenolphthalein and sulfophthalein indicators were found to result in ambiguous unstable endpoints.

mixed with two parts of the $MgSO_4$ solution. A 50 ml. aliquot of the resultant mixture was placed in the distillation vessel and the primary distillation run. Following the distillation the receiving vessel was removed. Then a fresh receiving vessel was prepared and attached to the apparatus. Twenty ml. of distilled water were added to the distillation vessel and a secondary distillation was run. Subsequent distillations were carried out in the same manner. The data and results are presented in Table 1.

TABLE 1

Rate of distillation of acetic acid or formic acid [1] from $MgSO_4$-acid solutions [2]

Distillation [4]	Acetic acid		Formic acid	
	ml. acid [3]	% distilled	ml. acid [3]	% distilled
Primary	3.32	90.0	2.81	73.2
Secondary	0.40	10.9	0.87	22.7
Tertiary	0.16	0	0.50	13.0
Quaternary	—	—	0.02	0.5

[1] The amount of acetic acid in a 50 ml. aliquot of sample was 3.69 ml. of 0.01 N acid; the amount of formic acid in a 50 ml. aliquot of sample was 3.84 ml. of 0.01 N acid.
[2] Determinations run in triplicate.
[3] Expressed as ml. of 0.01 N NaOH. The blank value averaged 0.44 ml.
[4] Each distillation required 4.7 minutes.

TABLE 2

Recoveries from serial and combined distillations of the volatile acids in a 50 ml. aliquot of an extract of halibut flesh [1]

Distillation	ml. acid [2] in distillate	% of total acid in distillate	ml. acid [2] in combined distillate	% of total acid in distillate
Primary	3.90	77.3	4.70	93.1
Secondary	0.94	18.6	—	—
Tertiary	0.21	4.1	—	—
Quaternary	0	0	—	—

[1] Determinations run in triplicate.
[2] Expressed as ml. of 0.01 N NaOH required to neutralize the acid.

A second series of experiments were carried out in the same manner with the exception that the recovery of the acid was determined only on the combined distillates of the primary and secondary distillations collected in the same receiving vessel. The data and results are shown in Table 3.

As a result of the data from these experiments it became clear that the procedure for the determination could be simplified by using only the primary and secondary distillations and the distillates collected in the same receiving vessel. Recovery tests of acetic acid and formic acid which were added to fish flesh were carried out by employing this procedure. A 10 ml. aliquot of a 0.05 N acid solution was added to a 200 g. aliquot of a halibut flesh homogenate prior to the addition of the $MgSO_4$ solution. The regular procedure for the preparation of the sample and the simplified distillation procedure was followed. The data and results are presented in Table 4.

Another series of experiments were carried out in order to determine if the rate of distillation of volatile acids in fish flesh is similar to that of acetic acid or formic acid. A sample of medium quality halibut flesh was prepared according to the method of sample preparation previously described. Primary, secondary, and subsequent distillations were carried out as in the determinations of the rates of distillation of the pure acid. The determination of the acids content in the fish flesh also was carried out using the combined distillate of the primary and secondary distillations collected in the same receiving vessel. The data and results are presented in Table 2.

TABLE 3

Recoveries of acetic acid or formic acid in the combined distillate from $MgSO_4$-acid solutions [1]

Acid	ml.[2] acid added	ml.[2] acid in distillate	% recovery of added acid
Acetic	8.26	7.70	93.3
Formic	9.20	8.15	88.6

[1] Determinations run in duplicate.
[2] Expressed as ml. of 0.01 N NaOH required to neutralize the acid.

A few experiments verified the results of Tomiyama and Harada *(8)* who found that the majority of volatile basic substances are distilled during the first five minutes of vacuum distillation. Therefore, detailed experiments to determine the rate of distillation of volatile basic compounds were not performed. However, recovery experiments of two concentrations of added ammonium-N as $(NH_4)_2SO_4$ were carried out. A 10 ml. aliquot was added to a homogenate of halibut flesh prior to the addition of the $MgSO_4$ solution. The regular procedure for the preparation of the sample and for the distillation was then followed. The data and results are presented in Table 5.

A series of replicate determinations of both volatile acids and volatile bases were performed on fresh and stale halibut flesh samples. The experimental results were analyzed statistically to determine the reproducibility of the vacuum distillation procedure. The data and results are presented in Table 6.

TABLE 4

Recoveries of acetic acid or formic acid when added to halibut flesh homogenates [1]

Acid	ml.[2] acid distilled from halibut flesh extract	ml.[3] acid added	ml.[2] acid distilled from halibut flesh extract with added acid	% recovery of added acid
Acetic	1.55	3.96	4.93	85.4
Formic	1.55	4.06	5.00	85.0

[1] Data are means of duplicate determinations.
[2] Expressed as ml. 0.01 N NaOH required to neutralize the acid distilled from a 50.0 ml. aliquot of extract.
[3] Expressed as ml. 0.01 N NaOH required to neutralize the acid.

TABLE 5

Recoveries of ammonium —N as $(NH_4)_2SO_4$ when added to halibut flesh homogenates [1]

mg. % NH_3-N added to halibut flesh homogenates	mg. % volatile basic-N in halibut flesh	mg. % volatile basic-N in halibut flesh with added $(NH_4)_2SO_4$	% recovery of added NH_3-N
31.4	17.2	48.5	99.7
152	11.5	172	106

[1] Data are means of duplicate determinations.

TABLE 6

Reproducibility of results from volatile acids and volatile bases determinations of halibut flesh using the vacuum distillation procedure

Determination	Time of storage of sample on ice (days)	Number of replicates (N)	Mean value ($\bar{X}$)	Standard deviation ($S_{\bar{X}}$)	95% limits of confidence
Volatile Acids	5	8	25.4[1]	±1.00	± 0.80 ($\pm 3.75\% \bar{X}$)
	17	9	174[1]	±2.18	± 1.60 ($\pm 0.92\% \bar{X}$)
Volatile Bases	6	9	10.2[2]	±0.33	± 0.40 ($\pm 3.92\% \bar{X}$)
	18	5	52.7[2]	±0.76	± 0.80 ($\pm 1.52\% \bar{X}$)

[1] Expressed as Volatile Acid Number.
[2] Expressed as mg. % -N.

DISCUSSION

Under the experimental conditions presented in this paper, the rates of distillation of pure formic acid and pure acetic acid (Table 1) are great when compared to those generally obtained by steam distillation *(5)*. Results presented in Table 2 demonstrate that the rate of distillation of the naturally occurring acids in halibut flesh is comparable to that of pure formic acid. These high rates of distillation of acids permitted the simplification of the determination resulting in the final

procedure presented in this paper. Data in Table 3 demonstrate that a satisfactory recovery can be obtained by the use of only two consecutive distillations and the distillates collected in the same receiving vessel.

Slightly lower recoveries of acetic acid and formic acid, when added to a halibut flesh homogenate, were noted (Table 4). Further studies are needed to account for these lower recoveries. However, the differences were slight and should not affect the applicability of the method to the determination of volatile acids content in fish flesh.

The greater-than-100% recovery of pure formic acid and pure acetic acid (Table 1) was due undoubtedly to a slight error in the blank value. Since these errors would be additive a greater-than-100% recovery is a reasonable expectation.

Recovery experiments shown in Table 5 indicate that the method is suitable for the determination of Volatile Basic-N Content. An excess recovery was noted only in an experiment which dealt with a very high ammonium-N concentration. The cause of the excess recovery is unknown. That the excess recovery is due to a secondary decomposition of nitrogenous compounds is quite doubtful. Tomiyama and Harada *(9)* have demonstrated that secondary decomposition does not occur under vacuum conditions at 75° C. They reported identical results of volatile basic-N contents of a sample when determined by vacuum distillation at 45° C. and at 75° C.

The reproducibility data presented in Table 6 indicates that the method is quite precise and should be suitable for the determination of the volatile acids content and the volatile basic-N content of samples.

Further experimentation may demonstrate a correlation between results obtained by the steam distillation procedures for the determination of these indices and the vacuum distillation procedure. However, it is doubtful that identical values for the Volatile Acid Number will be obtained with the two methods since the percent recoveries of the volatile acids differ in the two methods. When the apparatus for the steam distillation of volatile acids is properly adjusted, the recovery of acetic acid is 57 $\pm$ 2%, whereas in the vacuum distillation procedure the recovery is approximately 90%.

The addition of water and the second distillation as carried out in the volatile acids determination was found necessary to insure a high percent recovery of some of the less volatile acids, such as formic acid. In the volatile bases determination, however, this operation was found to be unnecessary. The majority of the bases are distilled over within the first two or three minutes and all of the volatile bases are carried over within the recommended five minute distillation period.

The advantages of the preparation of the sample extract by deproteinization with the $MgSO_4$ solution are two-fold. First, corrosive and dangerous precipitants, such as trichloracetic acid and phosphotungstic acid, are not handled; second, a single extract is prepared which is suitable for use in both determinations. In addition, the $MgSO_4$ extract, at a pH of 2.0, is stable for at least 12 hours at room temperature and 36 hours when stored at refrigerator temperatures.

The somewhat unusual construction of the apparatus has several advantages and was arrived at after considerable experimentation. A single straight tube or Liebig condenser, even of 600 mm. length, does not act as an efficient condenser. However, by angling two condensers, attached in series, a turbulence appears to be set up in the stream of vapors resulting in complete condensation. The rinsing operation of the distillate into the receiving vessel can be carried out more efficiently with this type of construction than with any other type of condenser. Furthermore, this type of construction is more economical of laboratory space and has the added advantage of placing the receiving vessel close to the distillation vessel. When properly arranged, the water bath with its attendant controls, the distillation vessel, the receiving vessel, the trap-bottle, and the stopcock regulating the vacuum within the apparatus, are all in a line within 18 inches of each other. It is, therefore, extremely easy for a worker to watch and control all aspects of the procedure during the determination.

The vacuum distillation procedure has two additional advantages to offer. First, the determinations are carried out in an extremely short period of time, and second, little time is wasted between determinations due to the simple and rapid method of cleaning the apparatus without dismantling.

SUMMARY

A method for the determination of volatile acids and volatile bases in fish flesh by a vacuum distillation procedure has been presented. The method has the advantages of extremely rapid determinations without sacrificing either accuracy or precision, as was shown by the results of the recovery and reproducibility tests.

A method of preparing a sample extract by deproteinization with an $MgSO_4$ solution was also presented. The extract is relatively stable and suitable for use in both determinations.

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Characterization of Pectin Changes in Freestone and Clingstone Peaches During Ripening and Processing[a]

H. L. Postlmayr,[b] B. S. Luh, and S. J. Leonard
Department of Food Technology, University of California, Davis, Calif.

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RIPE CLINGSTONE AND FREESTONE PEACHES differ greatly in texture. Clingstone peaches are characteristically firm and highly suitable for mechanical handling. Almost the entire clingstone crop is absorbed each year by the canning industry. On the other hand, freestone peaches are easily bruised at canning maturity, and special precautions during various stages of processing are necessary to avoid damaging the fruit's delicate texture *(22)*. The work of Nightingale, Addoms and Blake *(18)* indicated that protopectin and water-soluble pectin were the constituents chiefly responsible for the extreme difference in texture between ripe cling and freestone peaches. Appleman and Conrad *(2, 5)* demonstrated that as freestone peaches ripen, protopectin is transformed into water-soluble pectin. Investigations have already shown that lower storage temperatures retard the rate of water-soluble pectin formation and softening in freestone peaches *(2, 6)*. The firm, "non-melting" texture of ripe clingstones was attributed to the high retention of protopectin in thick, intact cell walls *(1, 4, 18)*, the soft, "melting" texture of ripe freestones to the low retention of protopectin in thin cell walls.

Texture is one of the important factors determining consumer acceptance of canned peaches. Although the effect of harvesting maturity and processing time on texture of canned freestones has been reported *(16, 17, 22)*, little information on canned clingstones is available. The present work was started (a) to evaluate, by the carbazole method, pectic changes during maturation of clingstone and freestone peaches, (b) to study the effect of maturity and processing time on the pectic substances and syrup viscosity, and (c) to determine by physical and organoleptic methods the effect of these factors on textural quality of the canned product.

EXPERIMENTAL MATERIALS AND METHODS

Peach samples. Approximately 700 pounds of Halford clingstone peaches were harvested from commercial orchards in the Yuba City area and sorted into four stages of maturity based on skin color as observed visually under a standard light source. The clingstones were passed through a Dudley size-grader, and only those measuring $2^{5}/_{16}$ to 3 inches in diameter were used for canning.

Approximately 650 pounds of Fay Elberta freestone peaches were harvested from commercial orchards in the Suisun area and sorted according to skin color into three stages of maturity. Extremely large and small fruits were discharged. Two hundred pounds of fruit with average pressure test of 8 pounds were ripened at 68° F. and 70% relative humidity for three days to reach an average pressure test of 0.85 pounds ($^{5}/_{16}$ in. plunger) and then canned in the same way as the rest of the samples. It should be pointed out that various maturity stages were based on visual color when the crop was at or very near to commercial harvesting time. This method of sampling may not be equivalent to samples taken at successive time intervals.

Canning. The samples were canned within 24 hours after harvesting, except for the batch of freestones that was further ripened.

Clingstone peaches were halved and pitted with a Filper twist pitter. The peach halves were peeled in a Cup-down peeler by spraying with a 1.8% sodium hydroxide solution at 212° F. for 15 seconds. They were held in the holding section for 60 seconds and then spray-washed with cold tap water. The same procedure was used for freestones except that the peaches were hand-pitted and peeled with a 1% sodium hydroxide solution.

A fill weight of 19.5 ± 0.1 oz. of peeled peach halves was hand-packed into No. $2^{1}/_{2}$ (401 x 411) plain tin cans with lacquered ends. To each can was added 10.5 ± 0.1 oz. of 40° Brix sucrose solution, and the cans were sealed in a mechanical vacuum double seamer under 15 inches of vacuum. The sealed cans were cooked in an Anderson-Barngrover continuous-type rotary cooker at 212° F. for 28.7 minutes. To study the effect of processing time, samples were cooked at 212° F. for 18, 24.7, 28.7, 32.7 and 40 minutes. The cans were cooled in water in a rotary cooler for 7 minutes and then stored for 3 months at 20° C.

Analyses of fresh peaches. Ten peaches were taken at random from each lot and analyzed concurrently with the canning operation.

Skin and flesh color. The ground color of the skin was determined by reference to standard plates in Maerz and Paul's *Dictionary of Color (14)*, under a standard 500-watt light source equipped with a blue filter. The flesh color was determined after removing a piece of skin about ½ inch in diameter from the cheek side of the peach.

Pressure test. Two Magness-Taylor pressure testers *(15)* equipped with $^{5}/_{16}$-inch plungers, and having pressure ranges of 0-30 pounds (for green fruit) and 0-10 pounds (for ripe fruit), were used to determine firmness. Readings were recorded as the plunger penetrated to a depth of $^{5}/_{16}$-inch on the peeled area of the fruit. Twenty determinations were obtained in each lot by taking readings on both sides of each fruit, with the mean of these determinations representing the average pressure test.

Total acidity. Ten-gram portions of the macerated sample were weighed into 250-ml. beakers in duplicate. To each sample was added 200 ml. of distilled water. The resulting mixture was titrated with 0.1N NaOH to pH value of 8 in a Coleman pH meter. Total acidity was calculated as percentage of citric acid on a fresh-weight basis.

Soluble solids. The soluble solids content of the macerate was determined by a Zeiss Opton Refractometer. Readings were corrected to 20° C. and expressed as degrees Brix (percentage of soluble solids).

Total solids. Approximately 10 g. of macerate were weighed accurately in duplicate into tared aluminum dishes. The slurry was dried at 70° C. under 27 inches of vacuum for 16 hours.

Determination of pectic substances. The colorimetric carbazole method, as described by McComb and McCready *(11)*, was used to determine the pectin content in various fractions. Results were expressed as percentage of anhydrouronic acid on both fresh fruit and dry basis.

Total pectin. The versene-pectinase carbazole method, as described by McCready and McComb *(12)*, was used to determine the total pectin content.

Protopectin. In this investigation the protopectin fraction was considered to be those pectic substances insoluble in water at room temperature; it therefore includes the versene-soluble

[a] Presented at the Sixteenth Annual Meeting of the Institute of Food Technologists, St. Louis, Missouri, June 11, 1956.

[b] Present address: Hawaiian Pineapple Co., Honolulu, T. H.

fraction. The fruit and syrup from five cans were disintegrated in a Waring Blendor for one minute. Then 25 g. of the slurry was mixed with 200 ml. of 95% ethanol and stirred occasionally for one hour. The alcohol-insoluble solids (AIS) were collected on a Whatman No. 2 filter paper in a Buchner funnel under slight suction, washed twice with 50 ml. of 95% ethanol and once with 20 ml. of purified ethanol. The moist AIS were treated with 300 ml. of distilled water and shaken occasionally for 18 hours in the presence of a few drops of toluene. The mixture was filtered through a Whatman No. 2 filter paper in a Buchner funnel containing 7 g. of Super-Cel. The residue was removed, extracted again with 600 ml. of distilled water, and sucked dry. The filtrate was discarded. Then 300 ml. of 0.5% versene solution (tetra sodium salt of ethylene-diamine tetra acetic acid) was added to the residue. The resulting mixture was adjusted to pH 11.5 with 1N NaOH and allowed to stand at room temperature for 2 hours. The mixture was acidified with 1N acetic acid to pH 5.0 and treated with 2 ml. of freshly prepared 10% pectinol solution for 8 hours in a stoppered flask in the presence of a few drops of toluene. The mixture was filtered through a Whatman No. 2 filter paper in a Buchner funnel under suction. The residue was extracted again with 300 ml. of distilled water. The filtrates were combined and diluted to 1,000 ml. This volume represents the protopectin fraction.

In the case of fresh fruit, the AIS were prepared by gradually adding 500 g. of the sliced fruit sample to 1,000 ml. of boiling 95% ethanol to prevent enzymic degradation of the pectin *(10)*. The AIS were washed three times with 500 ml. of 95% ethanol, once with 50 ml. of purified ethanol. They were then dried for 48 hours at room temperature under 27 inches of vacuum with a slow stream of dry air passing through the oven. A 0.5-g. portion of the dried AIS was used for extraction and analyses of pectin.

Versene-soluble pectin. This fraction contains pectic substances insoluble in water but soluble in 0.5% versene solution at pH 6.0 *(10, 19)*. Twenty-five g. of the sample were extracted successively with 300 and 600 ml. of distilled water as described in the protopectin procedure. The residue was mixed with 200 ml. of 0.5% versene solution, adjusted to pH 6.0 with 1N acetic acid, and allowed to stand at room temperature for 18 hours in the presence of a few drops of toluene. The insoluble residue was extracted again with 300 ml. of distilled water and sucked dry. The filtrates and washings were combined and diluted to 1,000 ml. A 100-ml. aliquot was adjusted to pH 11.5 with 1N NaOH and allowed to stand for 30 minutes. The solution was then readjusted to pH 5.0 with 1N acetic acid. Two ml. of freshly prepared 10% pectinol solution was added. The solution was allowed to stand for one hour, diluted to 250 ml., and used for the determination of versene-soluble pectin.

Versene-insoluble pectin. This fraction was calculated from the difference between the amount of protopectin and the versene-soluble pectin, both expressed as percentage of anhydrouronic acid, on the dry basis.

Water-soluble pectin. The difference between total pectin and protopectin contents represents the amount of water-soluble pectin.

Isolation and characterization of pectic materials. The fruit and syrup from five cans were disintegrated in a Waring blender for 1 minute. Then 500 g. of the slurry was mixed with 1,500 ml. of 95% ethanol and allowed to stand for one hour. The AIS were collected, washed three times with 500 ml. of 95% ethanol, once with 200 ml. of absolute ethanol, and then dried at room temperature for 48 hours under 27 inches of vacuum with a slow stream of dry air passing through the oven. Eight g. of the dried AIS was mixed with 700 ml. of distilled water and 5 g. of versene, and the pH of the resulting mixture was adjusted to 6.0. The mixture was shaken for 18 hours, heated to 55° C. in a water bath, and filtered through a Whatman No. 2 filter paper in a Buchner funnel containing 7 g. of Super-Cel and some moist paper pulp. The pectic substances in the filtrate were precipitated with three volumes of 95% ethanol containing 0.5 M HCl. The precipitate was separated from the alcohol solution by centrifugation and washed with 500 ml. of 95% ethanol. The residue was dissolved in 200 ml. of distilled water and reprecipitated with three volumes of 95% ethanol (without HCl). The pectin was washed consecutively with 500 ml. of 95% ethanol, 400 ml. of acetone, sucked dry, and washed again with about 400 ml. of acetone until free from chloride ion. The precipitate was dried for 48 hours at room temperature under 27 inches of vacuum with a slow stream of dry air passing through the oven. The dried precipitate was ground to pass a 48-mesh screen and stored in a desiccator containing anhydrous magnesium perchlorate.

Methoxyl content. The saponification method, as described by Owens and co-workers *(19)*, was used to determine the methoxyl content. One milliequivalent of sodium hydroxide is equivalent to 31 mg. of methoxyl group.

Intrinsic viscosity. Intrinsic viscosity of the pectin sample was determined by the method described by Owens *et al. (19)*. The viscosities of three pectin solutions (0.02, 0.05, 0.10% w/v) at pH 6.0, and containing 0.8 g. of NaCl and 0.2 g. of versene per 100 ml., were determined in an Ostwald viscosimeter at 25° C. The intrinsic viscosity was obtained by plotting the ratio of specific viscosity to pectin concentration (Nsp/C) against pectin concentration (c) on semi-log paper. The intrinsic viscosity was obtained by extrapolating the line joining the points to zero concentration.

Syrup viscosity. The contents from 5 cans of peaches were drained for 2 minutes through an 8-mesh screen. The syrups were combined and centrifuged for 30 minutes. The time required for 10 ml. of the centrifugate to flow through the capillary tube of an Ostwald viscosimeter at 30° C. was determined with an accuracy of one-tenth of a second. The flow times were also recorded for solutions containing 49, 73, 79, 84, 86 and 90% glycerol in water by weight. Specific gravities of the syrup and glycerol solutions were determined by using a Westphal balance. The apparent viscosities of the various syrup samples were expressed as centipoises by reference to known values of glycerol solutions *(21)*.

Kramer Shear-Press. Ten Kramer Shear-Press readings were made on five representative cans of peaches. Three peach halves were placed in the test cell box of the Shear-Press *(8)* for each determination. The pressure required for the plunger plates to shear through the peach halves was recorded. A gauge with pressure range of 0-1,000 pounds was used for canned clingstones and 0-100 pounds for canned freestone peaches. The plunger plates were operated at a speed of 2.2 mm./sec. and a hydraulic pressure of 800 pounds for clingstones, at 2.0 mm./sec. and 200 pounds for freestone peaches.

Analysis of variance was based on the method described by Snedecor *(23)*. The level of least significant difference (LSD) was calculated by the method described by Sheffé *(20)*.

Organoleptic evaluation of texture. A panel of 20 persons evaluated the texture of the canned peaches. A randomized complete block design was employed wherein each panel member received four samples for comparison. Evaluations were made once a day for 8 days.

The contents of 3 cans were sliced and mixed with the syrups. The judges were requested to score the coded samples for texture on a numerical scale ranging from 1 to 10, 1 representing an extremely soft sample, 10 an extremely firm one. In addition, the panel ranked the samples according to desirability of texture, with a value of 1 indicating the best texture and 4 the least desirable. The degree of significance of the texture scores was calculated by the same method as that for the Kramer Shear-Press readings described above. The significance of the texture ranks was determined by the critical ratio method as described by Krum *(9)*.

RESULTS AND DISCUSSION

Change in pectic substances during maturation. This investigation was confined to peaches in the latter stages of maturity in order to have samples closely resembling those used in commercial canning. The chemical and physical properties of the fresh peaches are shown in Table 1.

The pectic constituents of Halford clingstones with

TABLE 1

Chemical and physical properties of fresh peaches

Clingstone (Halford variety)								Freestone (Fay Elberta variety)							
Ave. pressure test, pounds	Skin color[1]	Flesh color[1]	Soluble solids %	Total acid[2]	Ratio of soluble solids to total acids	pH	Total solids %	Ave. pressure test, pounds	Skin color[1]	Flesh color[1]	Soluble solids %	Total acid[2]	Ratio of soluble solids to total acids	pH	Total solids %
10.40 ±2.38	9L3	9L4	12.71	0.649	19.60	3.72	14.40	11.92 ±3.67	11K1	10L3	10.48	0.553	18.95	3.87	11.80
9.82 ±2.18	9L5	9L5	13.40	0.526	25.50	3.82	15.18	7.94 ±3.73	10K2	10K2	11.19	0.441	25.40	3.98	12.40
7.45 ±1.43	9L6	9L6	15.48	0.458	33.70	4.02	17.28	1.92 ±1.22	10K5	10K4	12.28	0.407	30.20	4.00	13.60
5.14[3] ±2.36	9L7	9L6	15.91	0.357	44.60	4.22	17.69	0.85[4] ±0.26	9L5	9L4	11.90	0.434	27.40	3.90	12.67

[1] Based on standard color plates from Maerz and Paul's *Dictionary of Color*.
[2] Expressed as percent citric acid on a fresh fruit basis.
[3] Over-ripe; rubbery in texture.
[4] Stored at 68° F. for 3 days until the average pressure test dropped to 0.85 pounds.

average pressure tests of 10.4 to 5.1 pounds changed very slightly during maturation (Table 2). The protopectin content, which includes the versene-soluble and versene-insoluble fractions, ranged from 60.9 to 64.4% of the total pectic substances. The water-soluble fraction was 35.6 to 39.1% of the total pectic materials. The high retention of protopectin, with no apparent transformation to water-soluble pectin during maturation, confirms the earlier work of Nightingale and coworkers *(18)*, who associated the high protopectin content of clingstone peaches with their inherent firm texture. Previous investigations *(2, 5, 6, 18)* have made no mention of versene-soluble pectins. This fraction may also play an important role in maintaining peach texture during maturation for two reasons: (a) in the case of freestones, softening of texture was accompanied by a decrease in versene-soluble pectin, and (b) according to Kertesz, overwhelming evidence indicates that the middle lamella is composed of some water-insoluble pectic substances essentially similar in nature to calcium pectate *(7)*. The versene-soluble fraction was found to be from 46.6 to 54.5% of the protopectin content. Thus, about half of the pectic materials classified as protopectins in this experiment were rendered soluble by the removal of bivalent ions. When the pressure test decreased from 10.4 to 5.1 pounds, there were slight decreases in the versene-soluble fraction (from 1.46 to 1.18%) and the water-soluble fraction (from 1.72 to 1.38%), both expressed as percentage of anhydrouronic acids on the dry basis. This change in pectic constituents, although small, might explain in part the softening of texture in the pressure range studied. In addition, biochemical changes other than degradation of pectin molecules may also be involved, as Nightingale *et al. (18)* have found cellulose and hemicellulose to decrease slightly during the later ripening stages in clingstone and freestone peaches.

Significant pectic changes were detected in Fay Elberta freestones as the average pressure test decreased (Table 2). There was a definite transformation of protopectin into water-soluble pectin as the fruit ripened, which is in close agreement with the results reported by previous investigators *(2, 5, 6, 18)*. When the average pressure test of the fruit dropped from 11.9 to 0.85 pounds, a marked decrease in protopectin, from 72.0 to 28.7%, was noted, as well as an increase in water-soluble pectin from 28.0 to 71.3% of the total pectin. Thus, solubilization of protopectin was involved in the softening of the texture.

Effect of heat-processing on pectic changes. A comparison of the results of Table 2 with those of Table 3 shows that the protopectin content of Halford cling-

TABLE 2

Changes in pectic substances of peaches during maturation

Average pressure test, pounds	Total pectic substances as % anhydrouronic acid		Protopectin							Water-soluble pectin	
			Total		Versene-insoluble			Versene-soluble				
	Fresh basis %	Dry basis %	Anhydrouronic acid[1] %	% of total pectic substances	Anhydrouronic acid[1] %	% of total pectic substances	% of total protopectin	Anhydrouronic acid[1] %	% of total pectic substances	% of total protopectin	Anhydrouronic acid[1] %	% of total pectic substances
Clingstone												
10.40	0.63	4.40	2.68	60.9	1.22	27.7	45.5	1.46	33.2	54.5	1.72	39.1
9.82	0.62	4.08	2.59	63.5	1.32	32.4	51.0	1.27	31.1	49.0	1.49	36.5
7.45	0.67	3.87	2.49	64.4	1.33	34.4	53.4	1.16	30.0	46.6	1.38	35.6
5.14	0.68	3.83	2.42	63.2	1.24	32.4	51.2	1.18	30.8	48.8	1.41	36.8
Freestone												
11.92	0.59	5.00	3.60	72.0	1.62	32.4	45.0	1.98	39.6	55.0	1.40	28.0
7.94	0.59	4.76	2.79	58.6	1.41	29.6	50.5	1.38	29.0	49.5	1.97	41.4
1.92	0.53	3.93	1.68	42.7	0.84	21.4	50.0	0.84	21.3	50.0	2.25	57.3
0.85	0.52	4.11	1.18	28.7	0.58	14.1	49.2	0.60	14.6	50.8	2.93	71.3

[1] All anhydrouronic acid percents expressed on a dry weight basis of the fresh fruit unless otherwise noted.

TABLE 3
Pectic substances in peaches canned at different maturities[1]

Average pressure test, pounds	Total pectic substances as % anhydrouronic acid[2]	Protopectin								Water-soluble pectin	
		Total		Versene-insoluble			Versene-soluble				
		Anhydrouronic acid[2] %	% of total pectic substances	Anhydrouronic acid[2] %	% of total pectic substances	% of total protopectin	Anhydrouronic acid[2] %	% of total pectic substances	% of total protopectin	Anhydrouronic acid[2] %	% of total pectic substances
Clingstone											
10.40	3.82	2.16	56.5	1.05	27.5	48.6	1.11	29.0	51.4	1.66	43.5
9.82	3.55	2.02	56.9	0.89	25.1	44.1	1.13	31.8	55.9	1.53	43.1
7.45	3.47	2.03	58.5	0.93	26.8	45.8	1.10	31.7	54.2	1.44	41.5
5.14	3.41	2.10	61.6	1.04	30.5	49.5	1.06	31.1	50.5	1.31	38.4
Freestone											
11.92	4.25	2.29	53.9	1.08	25.4	47.2	1.21	28.5	52.8	1.96	46.1
7.94	3.86	1.82	47.2	0.81	21.0	44.5	1.01	26.2	55.5	2.04	52.8
1.92	3.93	1.15	29.3	0.47	12.0	40.9	0.68	17.3	59.1	2.78	70.7
0.85	3.94	0.68	17.2	0.30	7.6	44.1	0.38	9.6	55.9	3.26	82.8

[1] Cooked for 28.7 minutes at 212° F.
[2] All anhydrouronic acid percents are expressed on a dry weight basis of the fresh fruit (corrected for sucrose added during canning).

stones decreased during the 28.7-minute cooking period. The changes in the versene-soluble and versene-insoluble pectin were responsible for the decrease in protopectin content.

Pectic changes of Halfords canned at an average pressure test of 7.45 pounds and heat-processed for various periods are shown in Table 4. Within the range of 18 to 40 minutes cooking, some of the protopectin was converted to water-soluble pectin, the most pronounced conversion occurring between the 18 and 28.7 minute cooking. Little difference in protopectin content was found between the fresh peach and the sample cooked for 18 minutes. Total pectic substances also decreased slightly upon extended cooking. The decrease in protopectin was greater than the increase in the water-soluble pectin content. This may have been caused by degradation of the pectin material by heat to smaller fragments which were not precipitated in the alcohol solution used in this investigation.

The ripeness of fresh freestone peaches at the time of canning is an important factor influencing pectin changes during heat-processing. The pectin contents of four batches of peaches canned at different average pressure tests and cooked for 28.7 minutes are shown in Table 3. Peaches canned at higher pressure test lose more protopectin (both versene-soluble and versene-insoluble) than those canned at lower pressure test. Thus, the amount of water-soluble pectin formed depends upon the amount of protopectin in the fruit at the time of canning.

Variations in heat-processing time from 18 to 40 minutes cause only very slight change in the protopectin content of freestone peaches canned at an average pressure test of 0.85 pounds (Table 4). The fresh sample had a protopectin content of 1.18%, while the canned sample, which was processed for 18 minutes, contained 0.72%, only. Probably some of the protopectin was converted to water-soluble pectin during the heat-processing period.

Properties of pectic materials isolated from canned samples. The uronide content, degree of esterification and intrinsic viscosity of pectic materials isolated from peaches canned at various stages of maturity and heat-processed for different time intervals are presented in Table 5.

The degree of esterification of the pectin samples that were isolated from the canned clingstones decreased as the average pressure test of the fresh fruit decreased. This indicated that carboxyl groups were formed by hydrolysis of ester linkages in the pectin, either during

TABLE 4
Effect of heat-processing time on pectic substances in canned peaches

Heat processing time, min.	Total pectic substances as % anhydrouronic acid	Protopectin								Water-soluble pectin	
		Total		Versene-insoluble			Versene-soluble				
		Anhydrouronic acid[1] %	% of total pectic substances	Anhydrouronic acid[1] %	% of total pectic substances	% of total protopectin	Anhydrouronic acid[1] %	% of total pectic substances	% of total protopectin	Anhydrouronic acid[1] %	% of total pectic substances
Clingstone[2]											
18.0	3.69	2.52	68.3	1.27	34.4	50.4	1.25	33.9	49.6	1.17	31.7
24.7	3.63	2.27	62.5	1.11	30.6	48.9	1.16	31.9	51.1	1.36	37.5
28.7	3.47	2.03	58.5	0.93	26.8	45.8	1.10	31.7	54.2	1.44	41.5
32.7	3.46	2.06	59.5	0.99	28.6	48.1	1.07	30.9	51.9	1.40	40.5
40.0	3.46	2.00	57.8	0.99	28.6	49.5	1.01	29.2	50.5	1.46	42.2
Freestone[3]											
18.0	4.05	0.72	17.8	0.36	8.9	50.0	0.36	8.9	50.0	3.33	82.2
24.7	3.98	0.68	17.1	0.33	8.3	48.5	0.35	8.8	51.5	3.30	82.9
28.7	3.94	0.68	17.2	0.30	7.6	44.1	0.38	9.6	55.9	3.26	82.8
32.7	3.93	0.64	16.3	0.27	6.9	42.2	0.37	9.4	57.8	3.29	83.7
40.0	3.80	0.64	16.8	0.34	8.9	53.1	0.30	7.9	46.9	3.16	83.2

[1] All anhydrouronic acid percents are expressed on a dry weight basis of the fresh fruit (corrected for sucrose added during canning).
[2] Halford clingstones at average pressure test 7.45 pounds.
[3] Fay Elberta freestones at average pressure test 0.85 pounds.

TABLE 5
Properties of pectic materials isolated from canned peaches

Clingstone (Halford)							Freestone (Fay Elberta)						
	(1) Uronide content %	(2) Methoxyl content %	(3) Pectinic acid[1] %	(4) Methoxyl content in % on basis of (3)[2]	(5) Degree of esterification[3] %	(6) Intrinsic viscosity		(1) Uronide content %	(2) Methoxyl content %	(3) Pectinic acid[1] %	(4) Methoxyl content in % on basis of (3)[2]	(5) Degree of esterification[3] %	(6) Intrinsic viscosity
Ave. pressure test of fresh fruit in pounds.							Ave. pressure test of fresh fruit in pounds.						
10.40	64.33	9.42	68.58	13.74	84.19	9.6	11.92	74.70	9.05	78.79	11.49	70.40	6.8
9.82	66.40	9.31	70.60	13.19	80.82	9.4	7.94	66.40	8.58	70.27	12.21	74.82	5.7
7.45	64.33	8.70	68.26	12.74	78.06	8.2	1.92	65.38	8.41	69.18	12.16	74.51	1.98
5.14	64.33	8.21	68.04	12.07	73.96	7.2	0.85	63.30	8.09	66.95	12.08	74.02	1.93
Heat processing time, min.[4]							Heat processing time, min.[5]						
18.0	65.38	9.47	69.66	13.59	83.27	8.1	18.0	60.18	8.33	63.94	13.03	79.84	2.0
28.7	64.33	8.70	68.26	12.74	78.06	8.2	28.7	63.30	8.09	66.95	12.08	74.02	1.93
40.0	65.38	9.21	69.54	13.24	81.13	6.7	40.0	62.25	7.59	65.68	11.56	70.83	1.95

[1] $(3) = (1) + (2) \times \frac{14}{31}$. [2] $(4) = \frac{(2)}{(3)} \times 100$. [3] $(5) = \frac{(4)}{16.32} \times 100$. [4] Halford clingstone peaches, canned at 7.45 pounds pressure test (5/16" plunger). [5] Fay Elberta freestone peaches, canned at 0.85 pounds pressure test (5/16" plunger).

maturation or processing. Under the conditions of this experiment, extended cooking appeared to have no effect on the degree of esterification. Intrinsic viscosity of the pectin samples decreased from 9.6 to 7.2 as the fruit matured. This small decrease in intrinsic viscosity is an indication that ripening occurred in the absence of polygalacturonase. Results of the fresh pectin analysis shown in Table 8, which showed that only slight pectic changes occurred in clingstones during maturation, supports this hypothesis. Extended processing for 40 minutes caused a small decrease in intrinsic viscosity, which suggested that the longer heating time might have caused a partial degradation of the pectin molecule.

Maturity appeared to have little influence on the degree of esterification of pectin samples isolated from canned freestones. McCready and McComb *(3)* reported that the degree of esterification of pectin isolated from fresh "unripe" and "ripe" Elberta freestones was 86 and 89% respectively. The lower degree of esterification of pectin in canned peaches found in this investigation might be explained by (a) the effect of heating on the methyl ester linkage, since longer heating time was found to cause a significant decrease in the degree of esterification, and (b) partial deesterification of the peach pectin by the lye used in the peeling process. Intrinsic viscosity decreased markedly from 6.8 to 1.9 during maturation. It is possible that the pectic enzyme polygalacturonase may have hydrolyzed pectin in and/or between the cell walls during the latter stages of ripening. McCready and McComb *(13)*, however, detected no polygalacturonase in tree-ripened Elberta freestones. They found the intrinsic viscosity of pectin isolated from unripe Elberta freestones to be 10.0 while that from ripe fruit was 4.3. The lower intrinsic viscosity of the pectin from canned freestones could be caused by (a) the partial degradation of the pectin during heat processing, (b) further hydrolysis of the pectin by polygalacturonase during the first part of the peeling or heating process, or (c) degradation of the polygalacturonide chain by alkali during the peeling process. Ash and Reynolds *(3)* found free galacturonic acid in freestones ripened at 20° C., but not in tree-ripened fruit. They suggested that the production of free galacturonic acid in freestones ripened at 20° C. may have been due to a disturbance in the relationship between an inhibitor and polygalacturonase. This seems to indicate that enzymic hydrolysis by polygalacturonase may be a major factor causing decrease in intrinsic viscosity of pectin during maturation of freestones. Extended processing had no influence on the intrinsic viscosity of pectin in freestones canned at an average pressure test of 0.85 pounds. Probably the molecular size of the extracted pectin had been so thoroughly degraded during maturation that extended heating caused little further degradation. It should be noted, however, that changes in the molecular size of initially small pectin molecules may not necessarily exert a discernible effect on intrinsic viscosity.

Factors influencing syrup viscosity. The degree of ripeness of fresh cling and freestone peaches had a marked influence on the syrup viscosity of the canned product. Results shown in Table 6 indicate that syrup viscosity decreased with a decrease in the average pressure test in both varieties. Throughout all stages of maturity, the syrup viscorities of clingstone peaches were considerably higher than those of freestones. Syrup viscosity correlated well with the corresponding intrinsic viscosity of the extracted pectin samples.

TABLE 6
Effect of maturity and heat-processing time on syrup viscosity of canned peaches

Effect of maturity		Effect of heat-processing time	
Average pressure test of fresh fruit, pounds	Apparent viscosity of syrup at 30° C., centipoises	Heat processing time, min.	Apparent viscosity of syrup at 30° C., centipoises
Clingstone (Halford)		Clingstone (Halford)	
10.40	126.9	18.0	32.3
9.82	91.6	24.7	80.1
7.45	88.5	28.7	88.8
5.14	49.3	32.7	97.9
		40.0	121.3
Freestone (Fay Elberta)		Freestone (Fay Elberta)	
11.92	50.0	18.0	5.6
7.94	35.8	24.7	4.3
1.92	9.2	28.7	4.2
0.85	4.2	32.7	4.4
		40.0	4.4

This indicated that the length of the polygalacturonide chain was related, at least in part, to syrup viscosity. Longer heating time caused an increase in the syrup viscosity of clingstone peaches canned at optimum maturity, although the intrinsic viscosity of the pectin samples decreased upon extended heat processing. Therefore, it appears that the increase in syrup viscosity was caused by the increase in quantity of water-soluble pectic substances in the syrup, which were formed during cooking.

In the case of freestone peaches canned at average pressure test of 0.85 pounds, length of heat-processing time did not affect the syrup viscosity. This may be explained by the fact that (a) there was only a very slight change in the protopectin and water-soluble pectin contents among the samples cooked for different periods, as shown in Table 4, and (b) there was no difference in the intrinsic viscosity among the pectin samples isolated from peaches subjected to different heat-processing periods. Most likely, the water-soluble pectin is hydrolyzed during the ripening process to low molecular weight pectin or oligouronides, which are heat stable.

Factors other than the length of the polygalacturonide chain and amount of water-soluble pectin may also influence syrup viscosity. For instance, the concentration and kind of sugar, the concentration of calcium ion that may react with the carboxyl groups of pectic and pectinic acid of low methoxyl content, and the pH values of the syrup may all affect syrup viscosity. Since peach samples used in this investigation were canned in the same syrup, the differences in syrup viscosity among the samples may be explained by the difference in quantity and/or quality of water-soluble pectin in the syrup.

Influence of maturity and processing on texture. The texture of the canned samples as measured by the Kramer Shear-Press and a taste panel are shown in Tables 7 and 8. Within the range investigated, maturity of clingstone peaches had little influence on the texture of the canned product. Neither the Kramer Shear-Press nor the taste panel could detect any significant difference in the texture of clingstones that had been canned at average pressure tests ranging from 10.4 to 5.1 pounds. An extended heating period definitely softened the texture of cling peaches canned at an average pressure test of 7.45 pounds. Significant softening in texture occurred between the 18- to 24.7-minute and the 32.7- to 40-minute cooking periods. The panel showed a preference for canned peaches with softer texture which were cooked longer. The tasters frequently commented that the texture of clingstones cooked for 18 minutes was too firm. In the case of freestone peaches, ripeness of the fruit at the time of canning has a more important bearing on texture of the canned product. Both Kramer Shear-Press and organoleptic evaluations indicated significant difference in texture of freestones canned at average pressure tests of 11.9, 7.9, and 1.9 pounds. No significant difference in texture was detected between samples canned at average pressure tests of 1.9 and 0.85 pounds. For the samples canned at an average pressure test of 0.85 pounds and processed at different periods, ranging from 18 to 40 minutes, the difference in texture was not significant. The Kramer Shear-Press might, then, be used to measure the texture of canned peaches objectively since the readings correlated well with the results obtained by organoleptic methods.

The introduction of the cup-down spray lye-peeling method, which is replacing the conventional Dunkley

TABLE 7

Effect of maturity on the texture of canned clingstone and freestone peaches

Fresh fruit			Texture evaluation of canned samples			
			Texture score[2]		Texture rank[3]	
Ave. pressure test, pounds	Ratio of soluble solids to total acid	Kramer shear press reading[1]	Total score	Ave. texture score	Total score	Ave. texture score
Clingstone (Halford variety, heat-processed 28.7 minutes)						
10.40 ±2.38	19.60	140 ±18	244	6.59 ±1.75	105	2.84 ±1.02
9.82 ±2.18	25.50	134 ±15	230	6.22 ±1.68	80	2.16 ±1.14
7.45 ±1.43	33.70	132 ±17	227	6.14 ±1.73	101	2.73 ±0.95
5.14 ±2.36	44.60	144 ±15	217	5.86 ±1.74	84	2.27 ±1.20
		NS		NS		NS
						*
Freestone (Fay Elberta variety, heat-processed 28.7 minutes)						
11.92 ±3.67	18.95	121 ±13	281	8.03 ±1.35	118	3.37 ±1.02
7.94 ±3.73	25.40	91 ±17	211	6.03 ±1.36	80	2.28 ±0.90
1.92 ±1.22	30.20	49 ±6	121	3.46 ±1.33	79	2.26 ±1.04
0.85 ±0.26	27.40	38 ±4	106	3.03 ±1.50	73	2.08 ±1.03
		**		**		**
		NS		NS		NS
						NS

[1] Clingstone: LSD at 5% level = 23.10.
Freestone: LSD at 5% level = 17.21; LSD at 1% level = 20.92.
[2] Number of judgments: 37 for clingstone; 35 for freestone.
Clingstone: LSD at 5% level = 1.16.
Freestone: LSD at 5% level = 0.96; LSD at 1% level = 1.16.
[3] Number of judgments: 37 for clingstone; 35 for freestone.
Significance determined by critical ratio method of Krum *(11)*.
* Significant at 5% level.
** Significant at 1% level.
NS Not significant at 5% level.

lye-dipping method, has created a problem of toughening at the cling peach surface where the lye is applied. This is thought to be caused either by the effect of local heating on the surface by the hot lye or by the firming action of calcium ions. The calcium ions may come from the lye, the washing water, or the syrup, which combine with the carboxyl groups of demethoxylated pectins formed by the lye-peeling process. Control of heat-processing time, the amount of calcium in the water, and the addition of a calcium sequestering agent may help solve the problem.

TABLE 8
Effect of heat-processing time on the texture of canned clingstone and freestone peaches

Heat-processing time, min.	Texture evaluation of canned samples				
	Kramer shear-press reading[1]	Texture score[2]		Texture rank[3]	
		Total score	Ave. texture score	Total score	Ave. texture rank
Clingstone (Halford variety, average pressure test of fresh fruit: 7.45 pounds)					
18.0	181 ±22 *	295	8.19 ±1.43 **	133	3.80 ±0.47 **
24.7	146 ±30 NS	234	6.50 ±1.61 NS	85	2.43 ±0.84 NS
32.7	141 ±19 **	222	6.17 ±1.39 **	74	2.11 ±0.83 *
40.0	100 ±17	171	4.75 ±1.34	58	1.66 ±0.92
Freestone (Fay Elberta variety, average pressure test of fresh fruit: 0.85 pounds)					
18.0	38 ±4 NS	162	4.38 ±1.80 NS	83	2.59 ±1.18 NS
24.7	37 ±3	147	3.97 ±1.63	79	2.47 ±1.09
32.7	37 ±5	132	3.57 ±1.51	77	2.41 ±1.02
40.0	33 ±4	126	3.40 ±1.76	81	2.53 ±1.18

[1] Clingstone: LSD at 5% level = 29.24; LSD at 1% level = 36.08.
Freestone: LSD at 5% level = 1.12.
[2] Number of judgments: 36 for clingstone; 37 for freestone.
Clingstone: LSD at 5% level = 0.98; LSD at 1% level = 1.19.
Freestone: LSD at 5% level = 5.33.
[3] Number of judgments: 35 for clingstone; 32 for freestone.
Significance determined by critical ratio method of Krum (11).
* Significant at 5% level.
** Significant at 1% level.
NS Not significant at 5% level.

SUMMARY

The influence of maturity and processing methods on pectic changes, texture, and syrup viscosity of canned Halford clingstone and Fay Elberta freestone peaches was investigated. Pectic constituents of Halford clings change very slightly during maturation. High retention of protopectin is apparently the major factor responsible for their inherent firm texture. In the case of Fay Elberta freestones, protopectin was converted into water-soluble pectin during ripening, causing softening of the texture. About 50% of the protopectin was soluble in 0.5% versene solution at pH 6.0; this may also have an important effect on peach texture during maturation.

A partial conversion of protopectin into water-soluble pectin occurred during heat processing of both varieties. Processing time is important to texture and protopectin retention in canned clingstones. The panel showed an increasing preference for clings heat processed longer than 18 minutes. Pressure test of fresh clings had less influence on protopectin retention than did processing time. In freestones, ripeness of the fresh fruit at the time of canning was an important factor influencing texture.

The intrinsic viscosity of pectic materials isolated from canned clingstones by the versene extraction method decreased from 9.6 to 7.2 as the average pressure test of the fresh fruit decreased from 10.4 to 5.1 pounds. In contrast, intrinsic viscosity of pectins from canned freestones dropped sharply from 6.8 to 1.9 as the pressure test of the fresh fruit decreased from 11.9 to 0.85 pounds. The syrup viscosities of canned peaches were lower when riper fruits were used in canning. Extended processing time increased the syrup viscosity of clingstones canned at optimum maturity, but had no effect on the syrup viscosity of soft ripe freestones. The importance of pectin changes during maturation or heat processing, or both, to the texture and syrup viscosity of canned peaches is discussed.

Acknowledgment

The authors wish to express their appreciation to Professor E. M. Mrak for his kind interest and encouragement in this work and to Miss Marion Simone and Miss Rose Marie Valdes for their help in texture evaluation. We also wish to thank the Cling Peach Advisory Board of California for supplying peaches for this investigation and the Sugar Research Foundation for financial help in making the study possible.

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Using Glycerine with Water-Soluble Gums

J. B. Segur, E. L. Whittaker[a] and C. S. Miner, Jr.
The Miner Laboratories,[b] 9 South Clinton Street, Chicago, Illinois

Water-soluble gums are colloidal substances that "dissolve" or disperse in water to give more or less viscous solutions. Many of them produce gels at higher concentrations. Most of their uses depend upon these two characteristics. Any means of enhancing these characteristics or of improving the quality or stability of gum-using products is potentially valuable. Some of the important uses of gums are as thickening and dispersing agents in ice cream, chocolate syrup, pie fillings and jellies. They are also used in cosmetic lotions and pharmaceutical jellies. Any substance added to a gum for such uses must be physiologically harmless.

The value of glycerine as a humectant and a plasticizer is well known and it is frequently used with gums. In addition, we have observed that it will increase the viscosity of gum solutions and the stiffness of their gels when used to replace some of the water. Most gels which are damaged by freezing may be at least partially protected from freeze damage by glycerine. The amount to be used in a particular application must be determined by trial.

As a wetting-out liquid applied to a gum before the addition of water, glycerine greatly aids dispersion of the gum by reducing the formation of lumps.

In addition to the above advantages, glycerine is completely acceptable in food, drug, and cosmetic uses.

EXPERIMENTAL

The gums selected for testing are among those in common use (Table I).

Viscosity of solutions. Solutions of each gum were prepared in two concentrations, selected to give viscosities within the range measurable by the viscometer. Each concentration of gum was prepared with glycerine concentrations of 0, 5, 10 and 20%, based on the total solution weight. (The water used contained 0.2% of sodium benzoate as a preservative for the solution.) The ingredients for each solution were weighed into a beaker, the gum and glycerine being mixed before adding water. The mixture was then heated in a boiling water bath until all lumps had been dissipated. The solution was allowed to stand overnight to insure complete dispersion of gum particles. Water lost by evaporation was replaced, and the solution thoroughly mixed and brought to 25° C. Its viscosity was then measured with a Brookfield "Syncro-Lectric" Viscometer, Model LVF.

TABLE 1

Kind of gum	Grade or trade name
Acrylic	Carbopol 934
Agar	Bacto-Agar
Arabic	U.S.P.
Carrageen	Viscarin, standard, for solutions
Carrageen	Gelcarin, GS-180, for gels
Gelatin	Atlantic gelatin
Karaya	N.F.
Locust bean	
Methyl cellulose	Methocel 400
Pectin	Albedo No. 461 T-9
Pectin	Rapid Set No. 436
Pectin	Slow Set No. 451
Polyvinyl alcohol	Elvanol 71-21
Sodium alginate	Kelcosol
Sodium carboxymethyl cellulose	CMC 70 Premium
Starch, corn	Argo Corn Starch
Starch, corn	QM-60, acid hydrolyzed
Tragacanth	Super Quality, U.S.P.

Viscosity data are given in Table 2. Attempts were made to measure the viscosity of solutions of agar and of gelatin also but incipient gelation prevented satisfactory readings even in dilute solutions.

Viscosity readings with Brookfield viscometer indicated that, as expected, the gum solutions were thixotropic. This was evidenced by increasing viscosity readings as the viscometer spindle speed was reduced. Also, at a given spindle speed the smaller spindles generally gave higher readings, although this effect was not observed in every case. Different solutions of a given gum were therefore measured under uniform conditions of spindle size and speed. The only exception was with polyvinyl alcohol, where the two concentrations used could not be measured with the same spindle.

Stiffness of gels. One gel was prepared from each gum, the gum concentration in each being chosen to give a gel suitable for measurement with a penetrometer. Each gum was prepared

[a] Present address: Nuclear Instruments & Chemical Corp., 223 W. Erie St., Chicago, Illinois.

[b] Now a Division of Arthur D. Little, Inc.

with glycerine concentrations of 0, 5, 10 and 20%. (The water used contained 0.2% of sodium benzoate as a preservative for the gels.) Gum and glycerine were first mixed in a beaker, then the water was added. The mixture was heated for 40 minutes in a boiling water bath and stirred to break up lumps and give a uniform sample. Any loss of water was made up and the sample then transferred to a glass crystallizing dish (70 mm. diameter, 50 mm. depth) and kept in a closed container to prevent evaporation. The gel was allowed to age overnight,

TABLE 2

The viscosity of gum-glycerine-water solutions

Gum		Viscometer spindle		Brookfield viscosity, cps.			
				% glycerine concentration			
Kind	% Conc.	No.	r.p.m.	0	5	10	20
Acrylic	0.2	2	30	14	13	15	15
Acrylic	0.4	2	30	460	465	565	648
Arabic	5	1	30	6.0	5.0	6.0	8.0
Arabic	10	1	30	8.8	10.0	11.6	16.4
Carregeen (Viscarin)	1	3	12	320	370	440	600
Carregeen (Viscarin)	2	3	12	3800	4300	5000	7860
Karaya	1	2	30	15	18	26	30
Karaya	2	2	30	499	573	633	838
Locust bean	1	3	12	570	730	890	1200
Locust bean	2	3	12	7850	8820	9280	10,000
Methyl cellulose	1	2	12	34	33	45	80
Methyl cellulose	2	2	12	293	345	450	1463
Pectin, rapid set	1	2	60	21	21	23	29
Pectin, rapid set	2	2	60	92	110	130	178
Pectin, slow set	1	2	60	15	15	16	21
Pectin, slow set	2	2	60	41	48	56	78
Polyvinyl alcohol	5	1	12	43	45	53	84
Polyvinyl alcohol	10	2	12	788	734	1045	1761
Sodium alginate	0.5	3	30	180	200	228	420
Sodium alginate	1	3	30	1620	1700	2000	2840
Sodium carboxymethyl cellulose	1	2	12	45	58	63	80
Sodium carboxymethyl cellulose	2	2	12	338	500	563	873
Corn starch	1	1	30	8.0	10.0	9.4	13.0
Corn starch	2	1	30	54	72	78	84
Corn starch, hydrolyzed	1	1	30	3.4	3.8	4.0	4.2
Corn starch, hydrolyzed	2	1	30	4.4	6.2	7.0	8.8

or longer, to permit uniform distribution of water and establishment of the gel structure. Penetrometer[1] tests were then made, the average of 5 readings being taken for each sample. Weight and size of the penetrometer plunger were varied as required by the stiffness of each gel. Application of the plunger to a sample was for 5 seconds. Results of the tests are given in Table 3. Polyvinyl alcohol and gum arabic did not produce gels.

Resistance of gels to freezing. After being used in the penetrometer test, a portion of each gel was frozen for at least 6 hours at —20° C. and then allowed to come to room temperature. Observations were made of the occurrence of syneresis, change in structure, and change in appearance. Results are given in Table 3.

Acknowledgment

The work was sponsored by the Glycerine Division, Association of American Soap and Glycerine Producers, New York, New York.

[1] The penetrometer was an ASTM portable model. The face of the plunger was a flat disc. Discs of 6 and 12 mm. diameter were used.

TABLE 3

Penetration and freezing tests of gum-glycerine-water gels

Gum		Glyc. % wt.	Penetration test[1]			Freeze test
			Plunger		Average penetr.	
Kind	%		Diam.	Wt.		
Acrylic	10	0	12	104	5.7	No change
		5	12	104	5.3	No change
		10	12	104	5.6	No change
		20	12	104	4.9	No change
Agar	2.5	0	6	200	21.1	Syneresis
		5	6	200	21.7	Moderate syneresis
		10	6	200	20.8	Very sl. syneresis
		20	6	200	9.2	No change
Carrageen (Gelcarin)	3	0	6	150	9.6	Moderate syneresis
		5	6	150	7.1	Moderate syneresis
		10	6	150	2.7	Moderate syneresis
		20	6	150	0.9	Slight syneresis
Gelatin	8	0	6	100	11.0	Cloudy
		5	6	100	—	Slightly cloudy
		10	6	100	9.9	No change
		20	6	100	4.7	No change
Karaya	10	0	12	54	9.2	No change
		5	12	54	7.9	No change
		10	12	54	5.6	No change
		20	12	54	6.0	No change
Methyl cellulose	15	0	6	150	99	No change
		5	6	150	26	No change
		10	6	150	10	No change
		20	6	150	0	No change
Pectin albedo No. 461 T-9	15	0	6	50	bottom	No change
		5	6	50	bottom	No change
		10	6	50	17.1	No change
		20	6	50	10.4	No change
Sodium alginate	5	0	6	50	bottom	No change
		5	6	50	bottom	No change
		10	6	50	18.9	No change
		20	6	50	12.5	No change
Sodium alginate +0.2% Ca gluconate	5	0	6	50	9.5	Weakened
		5	6	50	6.4	Slightly weakened
		10	6	50	4.4	No change
		20	6	50	1.9	No change
Sodium carboxy-methyl cellulose	15	0	6	50	51	No change
		5	6	50	40	No change
		10	6	50	40	No change
		20	6	50	26	No change
Corn starch	15	0	6	100	15.7	R-1[2]
		5	6	100	14.4	R-1
		10	6	100	12.9	R-1
		20	6	100	3.9	R-2
Corn starch (hydrolyzed)	15	0	12	154	8.5	R-1,[2] spongy
		5	12	154	6.1	R-1, spongy
		10	12	154	2.8	R-2, spongy
		20	12	154	1.2	R-3, grainy
Tragacanth	10	0	12	54	8.3	No change
		5	12	54	7.0	No change
		10	12	54	5.9	No change
		20	12	54	4.7	No change

[1] Diameter of plunger is given in mm. Weight of plunger is given in grams. Application of plunger to gel was 5 seconds. Penetration, in mm., is the average of 5 readings.

[2] Abbreviations: R-1 = much retrogradation
R-2 = moderate retrogradation
R-3 = slight retrogradation.

Development of a Scale for Grading Toughness-Tenderness in Beef[a]

Elsie L. Raffensperger, David R. Peryam, and Kenneth R. Wood

Quartermaster Food and Container Institute for the Armed Forces, Chicago 9, Illinois

(Manuscript received June 16, 1956)

THE FORMAT OF RATING SCALES constructed for use in sensory evaluations has been left pretty much to conjecture and intuition. This was again demonstrated when the authors were confronted with the task of finding a scale to evaluate toughness-tenderness in unaged beef. The specific problem was to compare steaks from different grades, classes, and weight ranges of cattle on texture and flavor quality, and to relate these qualities to over-all consumer preference.

The literature had little to offer in the way of rating scales for the textural aspect. The fact was not even clearly established, though taken for granted, that toughness and tenderness lie on the same continuum of meaning and sensory discrimination. However, credit must be given to the U. S. Department of Agriculture, the American Meat Institute Foundation, and others who have found several versions of a bipolar toughness-tenderness scale to work with some degree of success. The only published report which included a systematic study of scale reliability was by Deatherage and Reiman *(2)*. They reported on a 0-10 scale with five specific anchor points, or verbal definitions, which showed satisfactory reproducibility of results in repeated tests with 6 subjects. They admitted, nonetheless, finding sizable fluctuations in standard deviation along various parts of the scale. However, with so few subjects it is not unlikely that erratic tendencies on the part of the individual subjects may have contributed greatly to the non-uniform scale pattern noted.

The present work involved constructing a scale "from scratch." The immediate task was that of developing a scale where every point would lie, psychologically, between its neighbors. Thus it was hoped, at least in part, to avoid the difficulty of fluctuating variances and the consequent necessity for mathematical transformation which, in a strict sense, is required by such non-homogeneity.

Work carried out by Jones, Peryam and Thurstone *(6)* in developing an optimal preference scale suggested that a technique similar to theirs might be fruitful in the present situation. A structured scale, i.e., one where every point is labeled, was chosen as the objective since evidence by Bendig *(1)* and others had shown that increased anchoring tended to result in slightly increased reliability. The issue between structured and unstructured scales, however, is not settled. The advantages found for one scale over another may depend closely on the respondents using the scale. Further clarification is needed on this point. Since the potential subjects in this experiment were accustomed to using structured scales of various kinds, it seemed reasonable to elect this approach.

[a] Presented at the Sixteenth Annual Meeting of the Institute of Food Technologists, St. Louis, June 13, 1956.

DEVELOPING THE SCALE

In the optimal scale work referred to above *(6)* the authors used a technique developed by Edwards *(4)* and based on Thurstone's method of successive intervals. This is a psychological scaling procedure in which stimuli are classified into successive intervals according to the degree of some defined attribute which they are judged to possess.

Here the stimuli were purely verbal, consisting of 41 words or phrases each of which might possibly be used in describing toughness or tenderness. In all, responses were obtained from 150 subjects. Figure 1 shows examples of the items and the three different schedules which were used. Schedule 1 is bi-polar, running from *greatest toughness* to *greatest tenderness*, whereas each of the other schedules specifies only one aspect, either *toughness* or *tenderness*. Subjects designated the meaning of each word or phrase by placing an "x" in the space judged most appropriate.

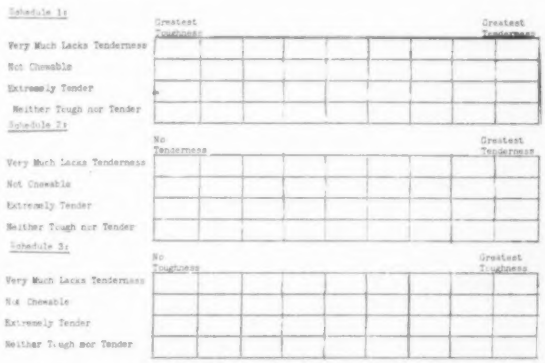

Figure 1. Three different schedules used in the word meaning test.

To assure that the scale would be understood by the several types of subjects who might use it, people representing a wide range of experience in taste testing were included among the 150 subjects. Two groups of 30 subjects each were chosen from technical personnel previously trained for sensory evaluation of meat products and who were generally familiar with the analytical approach to flavor. A third group of 90 subjects was chosen from non-technical personnel whose previous experience was limited to preference testing. Some groups of subjects repeated the test using a different schedule, the time interval between administrations being varied among groups. This was done to determine possible memory effects. The Kolmogorov-Smirnov test *(5)* applied to the distributions for the various subject groups showed no significant differences for any of the schedules. Hence the combined data were used in the further analyses.

The primary analysis was on data from the bi-polar schedule. For the subject group as a whole, normal distributions of response resulted for about half of the 41 words and phrases. Only these were considered for the scale. Where bimodality or skewness occurred, lack of normality could usually be traced to such factors as incongruity of meaning of the several elements within a phrase *(fairly tough)* or general ambiguity of meaning *(little tenderness.)* The standard deviation was calculated for each item and served as the primary indicator of ambiguity. The more agreement there is—the less ambiguity—the smaller will be the standard deviation.

Selection of descriptions for the 9 intervals of the scale was carried out as follows: The modal scale value for each phrase showing a normal distribution of responses was plotted against its standard deviation (Figure 2). The item nearest the midpoint of a given interval and which also had a low standard deviation was then chosen to represent that interval. The intervals appearing along the abscissa of Figure 2 are estimated. They were calculated from the total pattern of response on Schedule 1 for all 41 items combined.

The single-poled Schedules 2 and 3 were included in the study to help determine whether choice of a bipolar continuum was propitious. Schedule 2 was anchored by the end points *no toughness—greatest toughness*, and Schedule 3 by the end points *no tenderness—greatest tenderness*. A "squeezing" of responses in one direction or another, with overlapping of distributions for tender and tough terms, would have indicated that toughness and tenderness were not on the same continuum or that there was overlapping in meaning. It was found, however, that results from the three schedules did not differ markedly. Some restriction was noted within the *no toughness—greatest toughness* continuum; also there were slight changes in the order of terms near the center of the scale; however, these effects were not found with the continuum, *no tenderness—greatest tenderness*, which seemed to permit as much freedom of response and resulted in the same word meaning order as the bipolar continuum. Since neither of the two single-poled continua was superior to the bipolar, the latter was chosen as a basis for continuing the study because of its logical advantages.

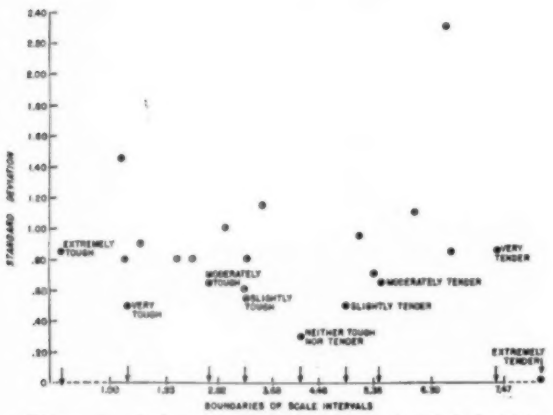

Figure 2. Scale value plotted against standard deviation for 23 words and phrases.

DETERMINING SCALE ADEQUACY

The next step was a pilot test to determine whether the scale had any obvious defects. A series of tests was run on unaged beef samples using the trained group of subjects described earlier. The two scales which were used are shown in Figure 3. One was the newly developed scale and the other was relatively unstructured, having only the end points anchored. The unstructured scale was introduced to test the hypothesis that structuring would give better results. If this hypothesis could not be accepted, comparison of results from the two scales might indicate ways in which the structured scale could be improved. The 36 subjects were divided into 4 separate groups of 9 subjects each. Two groups evaluated all samples using the structured scale; the other two groups used the unstructured scale. The scales were not interchanged among the subject groups because of the necessity of avoiding possible memory effects that might diminish scale differences. Nine treatments of beef were tested, representing 3 different cuts and 3 different grades. In order to avoid between-animal variability only one carcass was used to represent a specific grade and cut. Thus, any effect other than cut and grade could be attributed to either subject or scale.

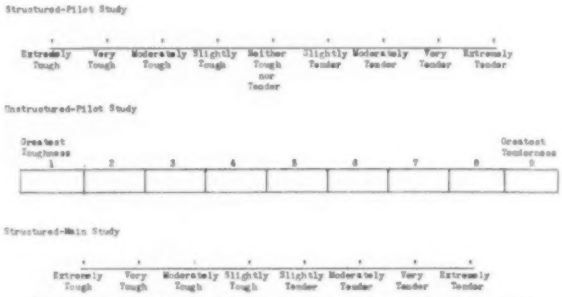

Figure 3. Rating scales used in the pilot and main studies.

Table 1 summarizes the pilot study results, giving the mean rating on each scale for each cut and grade. The range of grade means was almost identical for the two scales on two of the cuts but was somewhat greater for the unstructured scale in the case of the sirloin strip cut; however, analysis of variance showed that the effect of grade was significant beyond the 0.5% level for each scale on each cut. These data, therefore, have not necessarily demonstrated that either scale discriminated more effectively than the other. Error variance, calculated as judge-grade interaction, which would show the extent of agreement among individual judges, was determined for each of the scales. No significant difference was established.

The variance and average of the distribution of each judge's ratings were obtained and variances were plotted as a function of average rating. This was done for each of the scales. The distributions were analyzed to determine whether there were any systematic changes in variance along the scale and to estimate the proportion of the total variance that could be so attributed *(3)*. Any systematic change in variance might indicate characteristics of the scale that tend to create confusion in the neighborhood of the point of greatest variance. A superior scale should show a minimum of such systematic change; its error should be random. The structured scale had a significantly greater amount of systematic error than the unstructured scale—about 50% as compared to 20%.

Finally, the individual distributions of ratings for each scale, grade and cut were examined. In Figures 4,

TABLE 1

Mean ratings obtained from pilot study of 9-point structured and unstructured scales—toughness-tenderness continuum

Grade	Sirloin strip		Sirloin butt		Rib-eye	
	Structured	Unstructured	Structured	Unstructured	Structured	Unstructured
Choice	3.9	5.9	5.6	6.5	6.3	7.0
Commercial	5.2	5.9	4.7	5.7	3.4	4.3
Utility	2.9	2.8	2.8	3.8	5.6	6.3
Range of Means	2.3	3.1	2.8	2.7	2.9	2.7

5, and 6, cumulative proportions of response have been plotted against scale values. For those samples whose modal values are near the midpoint of the scale, a dip in the curve appears with the structured scale, indicating avoidance of this category. This midpoint was defined by the phrase, *neither tough nor tender*. Apparently subjects did not need this category or felt that it had no real meaning. A similar tendency to avoid the neutral category *neither like nor dislike* on the 9-point hedonic scale has been noted *(6)*. Since the

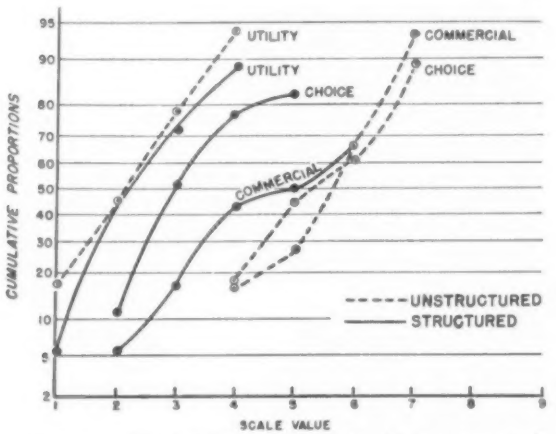

Figure 4. Distribution of ratings for sirloin strip cut obtained with 9-point structured and unstructured scales (pilot study).

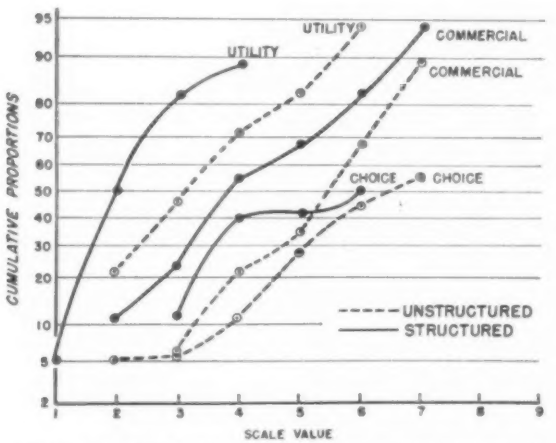

Figure 5. Distribution of ratings for sirloin butt cut obtained with 9-point structured and unstructured scales (pilot study).

systematic error for the structured scale was mainly parabolic in that higher variance occurred in the center, omitting the midpoint was considered as a means of reducing this variance.

In general, the pilot study did little to foster the idea that the structured scale was superior to the unstructured scale. This may have been another case where the adequacy of a scale was closely dependent upon the skill and training of the subjects. All of the subjects were very familiar with the use of structured scales and

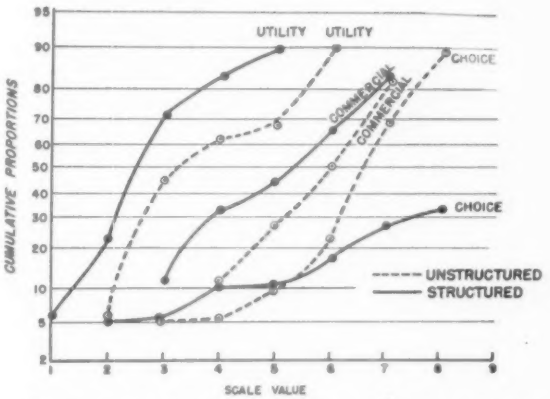

Figure 6. Distribution of ratings for rib-eye cut obtained with 9-point structured and unstructured scales (pilot study).

may have mentally structured the unstructured type. Furthermore, different subject groups were used in comparing the two scales so that group differences could have played a part.

FURTHER EVIDENCE OF SCALE ADEQUACY

After the evidence from the pilot study was evaluated, a structured scale of 8 points, with the neutral category omitted, was designed (Figure 3). The main study in which the scale was to be used involved the comparison of 21 treatments representing different combinations of grade, class, and weight range. Each treatment was represented by 20 different animals. About 30 trained panel members participated according to a planned experimental design. These data are discussed here only insofar as they pertain to the scale itself.

Since analysis of variance showed no significant main effects or interactions, all of the data were combined to study scale adequacy. This was done in two ways: (a) The variances of individual judge's ratings were analyzed as described above for the pilot study. The 8-point scale gave a definitely lower percentage of systematic error than that found in the pilot study

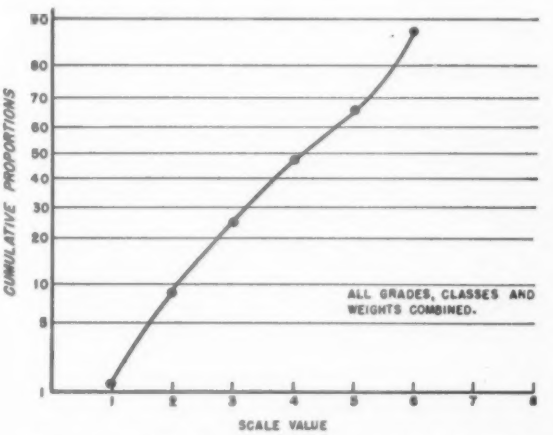

Figure 7. Distribution of ratings for sirloin butt cut obtained with the 8-point structured scale (main study).

for the 9-point structured scale—20% as compared to 50%. (b) The combined distributions of ratings were examined for all subsamples by plotting the cumulative distributions of responses as before. That for sirloin butt, which was typical, is shown in Figure 7. It is almost a straight line. Apparently the simple omission of the neutral category corrected the trouble previously noted for the 9-point scale.

CONCLUSIONS

What were the postive results of this study? What has it shown about scales either generally, or specifically in regard to the measurement of toughness-tenderness?

(1) Using Jones' "rating of word meaning" technique, it was demonstrated that a logical, completely structured scale could be developed.

(2) A bi-polar continuum appeared to be the most suitable although not clearly better than one of "tenderness" alone.

(3) With trained subjects a fully structured 9-point scale was apparently not superior to a 9-point unstructured scale.

(4) Elimination of the "neutral" category represented a definite improvement in the structured scale.

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Effect of Ionizing Radiations on Carotenoid Stability[a]

A. Lukton and G. Mackinney
University of California

(Manuscript received June 15, 1956)

In this paper, we report on the stability to gamma-radiation from a Co^{60} source, of carotenoids in tomatoes, carrots, and prawn, both fresh and cooked; in frozen spinach after thawing; in a mold *(Phycomyces)*, in commercial corn oil, in oils extracted from carrot roots and from salmon; in solid films of pure crystalline beta-carotene and lycopene; in petroleum ether solutions; and finally of lycopene dissolved in pure methyl stearate, methyl oleate and methyl linoleate.

EXPERIMENTAL

Source of materials.

Tomatoes. The size of the container in which samples were irradiated precluded the use of whole tomatoes of diameter greater than 2.5 cm. Occasionally as noted, small "cherry" tomatoes were used. For the most part, two types[b] were used, a red, high in lycopene, and an orange, high in beta-carotene. Tomato purées were prepared by macerating the fresh tomatoes in a blender, and then squeezing through four layers of cheesecloth to remove seeds and skin fragments. A purée was similarly prepared from canned solid-pack tomatoes.

Carrots. It was not practicable to irradiate whole carrots owing to their size. Raw carrots were macerated in a blender without addition of water. Commercially packed canned diced carrots were similarly treated.

Prawns. Raw prawns were shelled and ground in a mortar. After irradiation, prior to extraction, they were boiled for 4 minutes, so that they received the same heat treatment as boiled samples. The latter received 4 minutes in boiling water in the shell, after which they were shelled, ground and irradiated.

Spinach. A package of commercially frozen spinach was blended, and one sample was irradiated.

Phycomyces. Orange-colored mycelial mats of the mold *Phycomyces blakesleeanus* were washed on a Buchner funnel with distilled water to remove adhering medium, and blended fresh.

Oils. Carrot root oil was prepared by extracting 1 kg. fresh carrots with methanol in a Waring blender and then with petroleum ether. The methanol-containing extract was also transferred to the petroleum ether which was then evaporated nearly to dryness. The oil was transferred to the sample holder with petroleum ether which was then removed under vacuum.

Corn oil samples were obtained from a freshly opened bottle of commercially prepared oil (Mazzola brand).

Salmon oil was obtained by direct ether extraction of fresh salmon flesh.

Crystalline beta-carotene and lycopene. Samples of 50-100 mg. of crystalline carotene and lycopene were obtained from fresh carrots and tomatoes. Acetone extracts were prepared in the usual way, transferred to petroleum ether, washed and chromatographed on columns of magnesium oxide-celite (1:2). The eluates of the desired fractions were concentrated and crystallized from petroleum ether-ethanol solution. The petroleum ether was in all cases passed over silica gel prior to use.

Fatty acid esters. Samples of pure methyl stearate, methyl oleate and methyl linoleate were purchased from the Hormel Institute.

Handling of samples. Samples were irradiated at room temperature by exposure to gamma-rays from a Co^{60} source at the Stanford Research Institute. Where necessary, in the case of solutions and purees, samples were packed in dry ice, to and from location, and stored at 0° F. until analyzed.

When irradiated in nitrogen, the containers were evacuated and the vacuum was released with nitrogen, and this process was repeated three times.

Analytical methods. All samples, except for the pure pigment solutions and the oils (which were merely diluted with petroleum ether for determination of optical densities) were extracted with acetone. The extract was transferred to petroleum ether, which was then washed and dried with anhydrous sodium sulfate. Where pigment losses were heavy, in the

[a] Presented at the Sixteenth Annual Meeting of the Institute of Food Technologists, St. Louis, Missouri, June 12, 1956.

[b] By courtesy of Professor C. M. Rick. For a description of these tomatoes, see reference *(1)*.

case of the petroleum ether solutions of the pure pigments, the extracts were chromatographed. For those tomatoes containing lycopene, measurements were made at 500 mμ, for those containing beta-carotene, at 450 mμ, and for salmon oil, at 470 mμ, where the maximum for this carotenoid is found in petroleum ether solution. Numerous other measurements were made, but values at these wave lengths were used for computing destruction in the various samples.

RESULTS

Results are compiled in Table 1 indicating the change in absorption at selected wave lengths of petroleum ether solutions of pure beta-carotene and lycopene. The absorption maxima and minima of isolated breakdown products are listed in Table 2.

In Table 3 are listed the carotenoid contents, in μg per gram of tissues before and after irradiation. Values for the prawn carotenoid are given in terms of the optical density of the extract at 470 mμ. A similar procedure was used in Table 4 to demonstrate changes in the various oils as affected by the radiation.

TABLE 1

Absorption at selected wave lengths, after irradiation

1. Beta-carotene

Concentration 6.7 mg./l. rep x 10^6	D_{485}	D_{475}	D_{440}	D_{370}
Control	1.72	1.48	0.107	0.273
0.05	1.10	0.90	.240	.287
0.15	.351	.269	.321	.315
0.54	.009*	none	.138*	.314
1.06	.003*	none	.032*	.188
1.50	none	none	.024*	.164
2.00	none	none	none	.114
Concentration 33.5 mg./l.[1]				
Control	8.62	7.58	0.520	0.266
0.05	5.70	4.90	.975	.294
0.15	2.62	2.21	1.38	1.70
0.54	.013*	.029*	1.17*	1.775
1.06	.006*	none	.428*	1.505
1.50	.006*	none	.360*	1.275
2.00	none	none	.234*	1.045

2. Lycopene

Concentration 8.0 mg./l. rep x 10^6	D_{505}	D_{473}	D_{360}
Control	2.70	2.95	0.183
0.05	0.529	0.754	.466
0.1	.089*	.321	.413
0.2	.006*	.054*	.234
0.3	.008*	.047*	.232
0.4	.001*	.008*	.101*
0.5	none	none	.071*
Concentration 43.0 mg./l.[1]			
Control	13.84	15.11	1.25
0.05	6.51	7.59	2.63
0.1	3.21	4.18	2.78
0.2	.079*	.142*	2.71
0.3	.066*	.107*	2.45
0.4	.011*	.023*	1.93
0.5	none	none	1.68

[1] Densities calculated for solution as irradiated, not as diluted for spectroscopic measurement. * Peak no longer present.

The effect of the radiation on the whole tomato may be mentioned briefly. With dosages up to 0.5 million rep, no noticeable change in turgidity of the tomato was observed on storage for 18 days in the screw-capped vial. At dosages of 2 million rep and higher, a brownish watery exudate was observed after irradiation, which increased on standing. At 1.0 million rep some exudation occurred on storage. The critical dose above which tissue damage becomes serious appears to lie between 0.5 and 1.0 million rep.

DISCUSSION

A perusal of the data in Tables 3 and 4 shows a wide variation in the stability of carotenoids on irradiation. A film of solid lycopene in air showed a 2% loss at 2 million rep. Losses of this magnitude were also observed in raw tomatoes and carrots.

At this level, 2 million rep, the pure carotenoid in petroleum ether solution was completely destroyed.

TABLE 2

Absorption maxima and minima of breakdown products

1. Beta-carotene

Fraction*	Maxima	Minima
1	228 mμ	none
2 (beta-carotene)	478, 452, 275	470, 310, 255
3	425, 275, 252	380, 255
4	425, 275, 252	340, 255
5	425, 275	

2. Lycopene

1	none	none
2	485, 453, 428	470, 440, 375
3	485, 453, 428	470, 440, 390
4	445	380
5	360	345
6	445	none
7 (lycopene)	503, 490, 473, 445, 363	485, 455, 445, 320
8	none	none

* Listed in order in which components appear in the eluate.

TABLE 3

Pigment losses on irradiation of various types of pigment-containing tissues

Sample	Dose rep x 10^6	Beta-carotene μg./g. air	Beta-carotene μg./g. nitrogen	Lycopene μg./g. air	Lycopene μg./g. nitrogen	Astaxanthin $O.D._{485}$ air
Orange and red tomato type purees	none	76.6	80.8	63.6	72.3	
	5.95	75.5	80.4	55.4	63.3	
	none	82.2	83.0	100.8	102.1	
	12.0	81.1	79.1	99.0	103.1	
	none	83.0	99.0	100.0	100.5	
	20.0	74.5	82.0	89.5	83.0	
Cooked tomato purees	none			75.0		
	1			80.0		
	2			79.0		
	4			76.0		
Orange type tomato puree emulsified with methyl linolenate	none	69.0				
	1	66.0				
	2	65.0				
	3	65.0				
	4	65.0				
	5	64.0				
Whole red tomatoes after irradiation						
Days						
0	none			62.5		
	1			63.0		
	2			63.0		
4	none			61.5		
	1			65.5		
	2			66.0		
7	none			57		
	1			59.0		
	2			59.0		
11	none			56.3		
	1			60.5		
	2			59.0		
Raw carrot purees	none	122				
	1	128				
	2	123				
	4	98				
Cooked carrot purees	none	94				
	1	89				
	2	89				
Raw prawns	none					
	1					.393
	2					.218
	4					.239
						.164
Boiled prawns	none					.356
	1					.261
	2					.180
	4					.165
Mycelial mats of *Phycomyces*	none	609				
	3.42	180				
	none		701			
	0.5		705			
	1.5		765			
	5.0		407			

TABLE 4
Pigment losses on irradiation of pigment-containing oils

Sample	Relative concentration	Dose rep x 10^6	Optical density	
			air	nitrogen
Lycopene in methyl stearate	1	none	.332	
		.050	.306	
		.100	.315	
		.150	.305	
		.200	.277	
	2	none	.745	
		.050	.725	
		.100	.695	
		.150	.705	
		.200	.628	
	4	none	1.490	
		.050	1.421	
		.100	1.441	
		.150	1.441	
		.200	1.421	
Lycopene in methyl oleate	1	none	.332	
		.050	.113	
		.100	.060	
		.250	.015	
	2	none	.745	
		.050	.293	
		.100	.130	
		.250	.016	
	4	none	1.490	
		.050	0.750	
		.100	0.400	
Lycopene in methyl linoleate	1	none	.332	
		.050	.106	
		.100	.093	
		.150	.058	
		.200	.025	
	2	none	.745	
		.050	.209	
		.100	.160	
		.150	.148	
		.100	.040	
	4	none	1.490	
		.050	.549	
		.100	.355	
		.150	.274	
		.200	.078	
Beta-carotene in carrot oil		none	.390	.390
		.250	.374	.318
		.500	.375	.351
		1.00	.350	.327
Beta-carotene in corn oil		none	.113	.113
		.250	.122	.095
		.500	.112	.083
		1.00	.088	.073
Pigment in salmon oil		none	.498	.498
		.250	.393	.380
		.500	.300	.278
		1.00	.170	.113

For this reason, heat-treated carrots and tomatoes were also irradiated, on the supposition that the carotenoid dissolved in the lipide fraction would prove less stable to irradiation. Weier had early shown *(2)* that amorphous and semi-crystalline masses of carotenoid colored the oil droplets on heating the tissue. However, the cooked product also showed great stability. We therefore tested samples of oil, including an extract of the natural lipides of the carrot root.

Measurements were also made on samples of lycopene dissolved in pure fatty acid esters. The carrot root oil proved to be quite stable, with a loss of 10% in the carotenoid at 1 million rep, whereas 66% destruction was observed in salmon oil. The lycopene in methyl stearate, in the absence of any antioxidant, was much more stable than when dissolved in methyl oleate or linoleate. The carotenoid-protein complex in the prawn was also unstable. Hydrolysis of the complex by cooking is evidently not a significant factor.

We conclude that the losses incurred by carotenoids on irradiation depend upon the extent to which free radicals from the hydrocarbon solvent or peroxides from the lipide are available to react with the carotenoid. In this connection, it is of interest that losses in air are frequently slightly lower than in nitrogen. This would imply a competiton for the free radical between the oxygen present and the carotenoid. A peroxide formed from the fat would react much more slowly than a free radical with the carotenoid.

SUMMARY

The destruction of carotenoid pigments on exposure to gamma-radiation is caused by secondary reactions and depends upon the extent to which free radicals or peroxides formed in the surrounding medium are available for reaction. The loss of carotenoids in irradiated whole tomatoes is small even at dosages of several million rep, but the internal structure of the tomato is destroyed, and the problem is therefore one of pectin and carbohydrate instability. Three carotenoid-containing oils were tested; namely that extracted from the carrot root, corn oil, and salmon oil. The carotenoid in carrot root oil was very stable, and of the three oils tested, the pigment in salmon oil was least stable. Crystalline carotene and lycopene, dissolved in petroleum ether solution, in the absence of any antioxidant, are highly unstable. Stability was also markedly decreased, as would be anticipated, when pure lycopene was dissolved in methyl stearate, methyl oleate, and methyl linoleate, respectively in the order mentioned.

Films of pure beta-carotene and lycopene in the solid state appear to be remarkably stable, even in the presence of air, and we conclude that where destruction occurs, it is initiated by products of other reactions, normally to be sought in the lipide fraction. The differences in stability of the carotenoids in the natural oils examined may be explained in one or more of the following ways: the carotenoids themselves differ in each of the oils, the oils differ in their content of unsaturated fatty acid, and finally in their content of antioxidant. Whichever basis may be correct, one would predict the highest stability for the carrot oil and the lowest for the salmon.

Statement of Approval

This paper reports research undertaken in cooperation with the Quartermaster Food and Container Institute for the Armed Forces, and has been assigned number 642 in the series of papers approved for publication. The views or conclusions contained in this report are those of the authors. They are not to be construed as necessarily reflecting the views or indorsement of the Department of Defense.

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Cloud Stability of Frozen Superconcentrated Citrus Juices[a]

R. J. McColloch,[b] R. G. Rice,[c] Bruno Gentili, and E. A. Beavens

Fruit and Vegetable Chemistry Laboratory, Western Utilization Research Branch, Agricultural Research Service, United States Department of Agriculture, Pasadena, California

HIGH-DENSITY FROZEN ORANGE SUPERCONCENTRATES have been shown to have commercial advantages over present 4-fold frozen orange concentrate. Six-fold frozen orange concentrates not only possess greater cloud and flavor stability than the 4-fold products, but they require less packaging and storage space. Further, six-fold superconcentrates are more easily handled and reconstituted because they expand only negligibly on freezing and they remain plastic at 0° F. *(3, 9)*.

Previous studies with California concentrates have shown the comparative cloud stability of 4-fold orange concentrates and orange superconcentrates at constant storage temperatures *(9)*. However, comparative studies did not include heat-treated California orange superconcentrates or fluctuating-temperature conditions. Recent studies *(1)* in Florida have shown superior cloud stability for 58.5° Brix product as compared with 42° Brix when tested at 40° F.

Part I of this report presents experimental results on the comparative cloud stabilities of heated and unheated 4- and 6-fold orange concentrates at constant temperature and under conditions of fluctuating temperature likely to be encountered during commercial distribution. Part II reports research on the causes of superior cloud stability of superconcentrates.

PART I—CLOUD STABILITY OF SUPERCONCENTRATED AND 4-FOLD ORANGE JUICE CONCENTRATES UNDER VARIED CONDITIONS

Experimental materials. The freshly manufactured *(5)* California orange concentrate used in these studies was an unheated commercial 58° Brix product without cut-back juice added. The concentrate contained 4.7% acid as citric acid, 0.003% recoverable oil, and 8% pulp (v/v). The Brix-acid ratio was 12.3. An 8-gallon batch was flavor-fortified by addition of 10.90 ml. of cold-pressed orange peel oil, giving a total recoverable oil content of 0.009% on a 12° Brix basis.

One portion of this fortified concentrate was canned and frozen at 58° Brix (6-fold). Another portion was diluted to 42.5° Brix (4-fold) and canned and frozen. The remaining 58° Brix fortified concentrate was heated by steam-injection *(5)* for 1 second at 150-160° F. A portion of the heat-treated concentrate was canned and frozen as 6-fold product and the remaining heat-treated concentrate was diluted to 42.5° Brix (4-fold) with distilled water and canned and frozen. The heated and unheated 4- and 6-fold concentrates were placed in storage at 0° F.

Time-temperature patterns. Two time-temperature patterns were employed to compare cloud stabilities of the samples. In one case the samples were withdrawn from 0° F. storage and placed at 40° F. for 2 weeks. Cloud was examined in these samples every other day.

In the second time-temperature pattern, samples were stored for one month at 0° F. and then placed at 10° F. for 5 days. At the end of 5 days' exposure at 10° F. samples of each type of concentrate were (a) subjected to a slowly rising temperature which reached 20° F. in 5 days, (b) subjected to a slowly rising temperature which reached 40° F. in 5 days. These samples were then rapidly re-frozen to 0° F. A diagrammatic scheme of these time-temperature patterns is shown in Figure 1. For future reference, the cycles in Figure 1 and the samples exposed to them will be identified by the numbers 0, 20, and 40, referring to the highest temperature reached during the cycle. Cloud was determined in this experiment when the samples were first withdrawn from 0° storage and immediately after the samples were refrozen at 0° F.

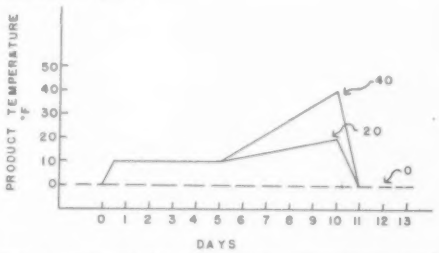

Figure 1. Plot of the fluctuating temperature conditions.

Flavor studies. At the end of the 20° and 40° F. constant temperature, and the fluctuating-temperature studies, samples were taste-tested in comparison with 0° F. controls for flavor differences. The triangular procedure was used *(9)*.

Cloud determination. Cloud was determined in the experimental samples by the method of Loeffler *(6)* with the modifications previously described *(8)*.

RESULTS AND DISCUSSION

The results of studies of cloud stability following storage at 40° F., shown in Figure 2, could have been expected from previous work *(3, 9)*. They confirm the fact that cloud stability in unheated 6-fold superconcentrate is equal to or slightly greater than that of a moderately heat-treated 4-fold orange concentrate. The cloud stability of the 6-fold heated superconcentrate is remarkably high, indicating that this product is practically immune to conditions which cause excessive cloud loss in present commercial orange concentrates.

The time-temperature patterns of Figure 1 were

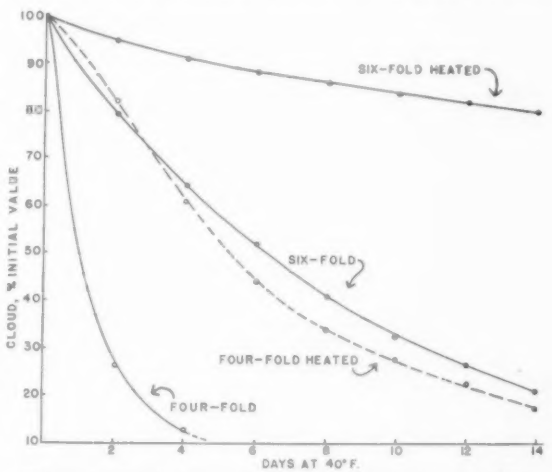

Figure 2. Cloud changes in orange concentrates at 40° F.

[a] Presented at the Sixteenth Annual Meeting of Institute of Food Technologists, June 13, 1956, St. Louis, Mo.

[b] Present address, Department of Agricultural Research Chemistry, University of Wyoming, Laramie, Wyoming.

[c] Present address: Chemical Abstracts, Ohio State University, Columbus, Ohio.

chosen as representing the most likely patterns of temperature abuse to which orange concentrate might be exposed in transit from the point of manufacture to wholesale or retail outlets. The results shown in Figure 3 demonstrate that this relatively moderate temperature abuse will result in noticeable cloud loss in the 4-fold unheated concentrate. On the other hand 4-fold heated orange concentrate and 6-fold unheated concentrate retained their cloud well through the 20° F. cycle and suffered a minor but noticeable cloud loss through the 40° cycle. As in the constant-temperature studies, unheated 6-fold concentrate appears to be slightly more stable than the heat-treated 4-fold product. The 6-fold heat-treated concentrate remains almost entirely free of cloud loss during both the 20° and the 40° F. cycles.

No flavor changes were detected in any of the samples during the course of these studies.

SUMMARY AND CONCLUSIONS

It is apparent from the results with constant and fluctuating temperature that unheated 6-fold orange superconcentrates possess approximately the same resistance to loss of cloud during temperature abuse as is obtained in 4-fold concentrates by mild heat treatment of 150-160° F. for 1 second. Mild heat treatment applied to 6-fold superconcentrates results in a product with very superior cloud stability.

PART II—CAUSES OF ENHANCED CLOUD STABILITY IN ORANGE SUPERCONCENTRATES

The superior cloud stability of orange juice concentrated at levels above about 42° Brix (4-fold) has been well established *(3, 9)*. It is also now well known that cloud stability in orange juices varies in a regular way with concentration *(2, 4, 10)*. The rate of cloud loss in orange juices increases from a low rate in single-strength juice to a maximum rate in 4-fold concentrates. Above 4-fold concentration, the rate of cloud loss decreases with increasing concentration.

It has been shown *in vitro* that increasing concentrations of divalent cations will bring about activation of pectinesterase (PE) followed by reduction of activity at still higher concentrations, and it has been suggested that this effect of cations on PE might occur in juice concentrate *(7)*, thus producing varying degrees of cloud stability at various concentrations. However, reported divalent cation concentrations in oranges vary considerably *(7)* and it would seem that this variability should result in a variation in the concentration giving minimum cloud stability among orange juices from different localities and prepared at different times. On the contrary, the concentration of minimum cloud stability is limited to a narrow concentration range of 35°-42° Brix *(2, 4, 10)*. This fact suggests the influence of constituents whose proportions vary only little in orange concentrates.

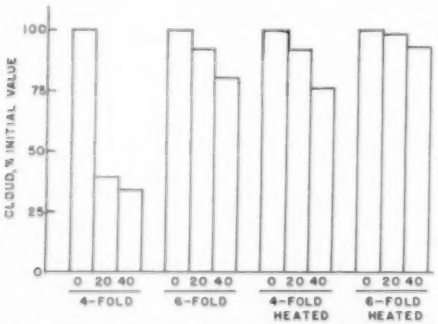

Figure 3. Cloud changes in orange concentrates during exposure to the fluctuating temperatures of Figure 1.

Sugars and acid fit this condition, since the proportions of sugar and acid are used to determine the suitability of fruit for processing, and the concentration of orange juice products is defined in terms of the Brix made up largely of sugar and acid. In addition the absolute amounts of sugar and acid in orange products are so large that small normal variations represent only small percentages of the total amounts present.

Studies were therefore conducted to determine the respective effects of calcium-ion concentration and of sugars-plus-citrate concentration on cloud stability in orange concentrates.

EXPERIMENTAL

Effect of calcium-ion on cloud stability. Orange concentrate of 42.5° Brix (4-fold) was prepared by diluting the 58° Brix commercial concentrate, described in Part I, with distilled water. From published figures it was assumed that this product was approximately 0.10*M* with respect to divalent cation content. The concentrate was divided into 4 aliquots, one of which was a control. To the other 3 aliquots were added 0.02, 0.06, and 0.10 mole of calcium ion (as $CaCl_2$), respectively, simulating 5-, 6-, and 8-fold concentration with respect to divalent cation. These samples were stored at 40° F. and cloud determinations made after 0, 17, and 22 hours. In determining cloud, the samples were reconstituted to single strength and held at 86° F. for 1 hour before centrifuging. The values obtained therefore represented the result of cloud loss which occurred during the holding periods as concentrate plus any additional cloud loss which occurred during the one-hour holding period as single-strength juice.

Effect of sugars and citrate on cloud stability. Normal orange juices of various degrees of concentration were prepared by diluting the 58° Brix commercial concentrate with distilled water. The soluble-solids concentrations employed were 12°, 23°, 33°, 42.5°, 51°, and 58° Brix, representing 1-, 2-, 3-, 4-, 5-, and 6-fold orange concentrates. These preparations were termed "folded" orange juices. A mixture of the sugars sucrose, glucose, and fructose in the ratio 2:1:1 was prepared as well as a mixture of citric acid and trisodium citrate 2:1. The mixtures of sugars and citrate were then blended in the ratio 11:1. This final mixture could be added to orange juices without altering the pH or sugar/acid ratio significantly.

To portions of the reconstituted single-strength juice sufficient amounts of the sugars-citrate mixture were added to give a series of products having an effective concentration of 2-, 3-, 4-, 5-, and 6-fold based on the above soluble-solids scale. In the same way products of 3-, 4-, 5-, and 6-fold concentration (effective) were prepared from reconstituted 2-fold orange concentrate.

The series of "folded" orange juices and the series of concentrates, simulated from 1- and 2-fold orange juice by appropriate additions of sugars and citrate, were stored at 40° F. Cloud was determined on these samples at the beginning of the storage period and after 24 hours at 40° F. From the data it is possible to construct a plot of cloud loss versus concentration for the series of real and synthetic orange concentrates.

RESULTS AND DISCUSSION

The effect of added calcium ion on cloud stability in 4-fold orange concentrate is shown in Figure 4, which shows that increased calcium-ion content, even at excessive levels equivalent to the divalent cation content of 8-fold concentrate, accelerated cloud loss. Furthermore,

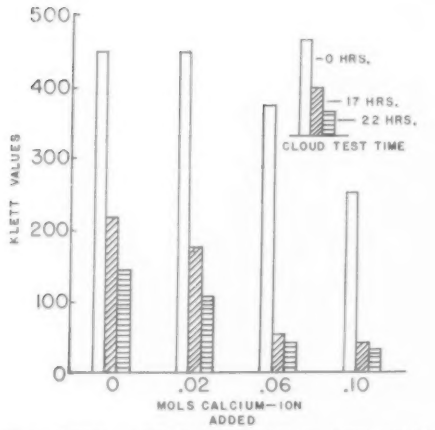

Figure 4. Effect of added calcium-ion on cloud stability of 4-fold orange concentrate at 40° F.

the decrease in cloud at zero time in the samples containing 0.06 and 0.10 mole of added calcium ion represents cloud loss which occurred in the reconstituted single-strength juice during the 1-hour holding period before centrifuging.[6] The figure therefore shows that increasing concentrations of calcium ion not only accelerate cloud loss in 4-fold orange concentrate, but at sufficiently high levels of concentration will cause marked cloud loss in single-strength juice.

These results can be interpreted as indicating either that concentrations of calcium ion which were found to reduce the activity of PE *in vitro* (7) do not produce this reduction of activity in orange concentrates, or that if reduction of PE activity does occur, it does not result in the expected effect on cloud stability.

The interesting effects of varying concentrations of sugars and citrate on cloud stability are shown in Figure 5. The curve for "folded" orange juice demonstrates the typical relationship of cloud stability to concentration which prevails in orange juices and concentrates. It is noteworthy that this same relationship was reproduced in 1- and 2-fold orange juices merely by adding sugars and citrate to simulate higher concentrations. This is shown by the curves for orange juice with sugars and citrate added and for 2-fold orange juice with sugars and citrate added. As might be expected from the results shown in Figure 5, one may also obtain enhanced cloud stability in 4-fold orange concentrates by artificially increasing the sugar and citrate concentrations.

It appears from these results that the variation of cloud stability with variation of concentration of orange juices is definitely associated with the changing concentrations of sugars and citrate. The mechanism by which varying concentrations of sugars and citrate affect cloud stability is unknown. However, data to be presented in a later paper will show that it is unlikely that the mechanism involves an effect on PE activity.

[6] It can be demonstrated that this loss of cloud at zero time does not occur in these samples when the samples are reconstituted and centrifuged immediately.

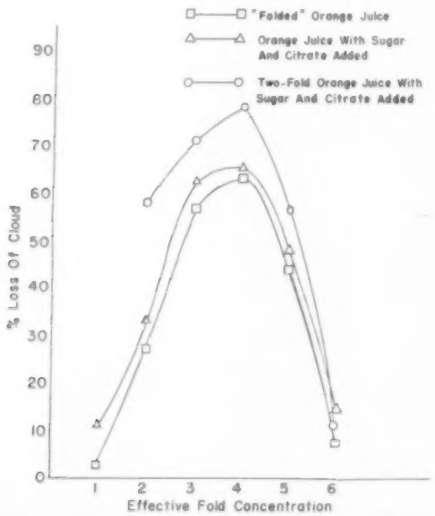

Figure 5. Comparison of cloud loss versus concentration in orange juice concentrates and in concentrates simulated by adding sugars and citrate to orange juices. 24 hours, 40° F.

SUMMARY AND CONCLUSIONS

The enhanced cloud stability of orange superconcentrates of greater than 4-fold concentration does not appear to result from reduced activity of pectinesterase due to high divalent cation concentrations as might be supposed, but appears to result from the effects of varying concentrations of sugars and citrate. Through a mechanism as yet undefined, the typical relationship of cloud stability to concentration in orange concentrates appears to be almost completely determined by the concomitant variations in sugars and citrate concentrations.

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A Simple Apparatus for Determining Gas Permeability of Flexible Films[a]

R. Henderson and G. A. Wallace
Film Division, Olin Mathieson Chemical Corporation, 275 Winchester Avenue, New Haven, Connecticut

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THE GAS PERMEABILITY characteristics of a flexible food packaging film are important in deciding its end use applications. It is desirable to determine these characteristics under conditions approximating those encountered in the specific packaging use, since under such conditions more useful results can be obtained.

Selection and specification control of flexible packaging films for use in vacuum and inert gas packaging of foods would be easier if there was a suitable method of measuring gas permeabilities of low permeability films. Methods, such as that of Landrock and Proctor *(2)*, for determining gas transmission rates of films using two different gases at the same pressure on opposite sides of the film sample, and depending on partial pressure differences as the driving force, are not sufficiently accurate. Commercially available equipment which uses gas on one side of the film, a vacuum on the other side, and measures permeability manometrically is expensive and fragile.

As the use of flexible packaging films in the food business has grown, there has been an increased demand for low permeability films. It was necessary, therefore, to design an apparatus and establish a procedure which would measure permeation rates under vacuum and which would give reproducible results in a reasonable length of time. The apparatus described is not new in principle as it employs essentially the same manometer system as reported in other published articles *(4, 5)*. The cell portion of the apparatus, however, is new and greatly simplified in comparison to other methods. It consists of a modified bacteriological pressure filter built to specification by the Republic Seitz Filter Corporation. The apparatus is relatively simple to operate, approximates the conditions of vacuum packaging and is fast and reproducible.

EQUIPMENT AND METHOD

Figure 1 shows the apparatus as it is mounted and used in the laboratory. The base plate is wood and the backing plate is plexiglass. The manometer is cushioned with rubber tubing and wired to the backing plate. This arrangement gives excellent support to the glass portions of the apparatus and eliminates stresses that lead to breakage.

Figure 2 is a drawing of the major working portions of the apparatus. In mounting the film sample, a filter paper (F) is placed on the cell base (G) within the lip (P). This paper allows the permeated gas to flow to the top of the capillary leg. The film (E) is then placed over the lip (P) and the rubber gasket (D) placed on top of the film. The cell cover is put in position and bolted finger-tight by the bolts (N). The manometer system is evacuated through the outlet (H) for about five minutes, or until the desired pressure differential across the film is obtained. In the work reported here, the differential pressure was approximately 740 millimeters.

Figure 1

Stopcock (I) is then closed. The entire apparatus is tipped counterclockwise until sufficient mercury has been poured from the reservoir (J) to fill the manometer legs to the level (L). A zero reading of the mercury level in the capillary leg is taken. If volatile materials are present in the film sample, the rate of fall of mercury will not be constant until all such volatiles are removed from the film. Therefore, a sufficient number of readings are taken to include several which indicate a constant rate of fall of mercury level. By use of the gas laws, the volume and area constants of the system and the change of mercury level in the capillary, the permeability of the test film can be calculated in ml. gas/m.^{2}/24 hrs./pressure differential applied.

Permeability value. The permeability value of a film sample can be calculated as follows:

$$\frac{\Delta p}{760} \times V \times \frac{273}{T} \times \frac{1}{A} \times \frac{24}{t}$$

ml. gas at standard temperature and pressure m^2/24 hrs. where

Δp = Pressure change in millimeters of mercury at constant rate for time t.

t = Time interval in hours.

V = This is the free volume from the top of the initial level of mercury in the capillary to the film sample and includes the free space in the

[a] Presented at the Sixteenth Annual Meeting of the Institute of Food Technologists, St. Louis, Missouri, June 12, 1956.

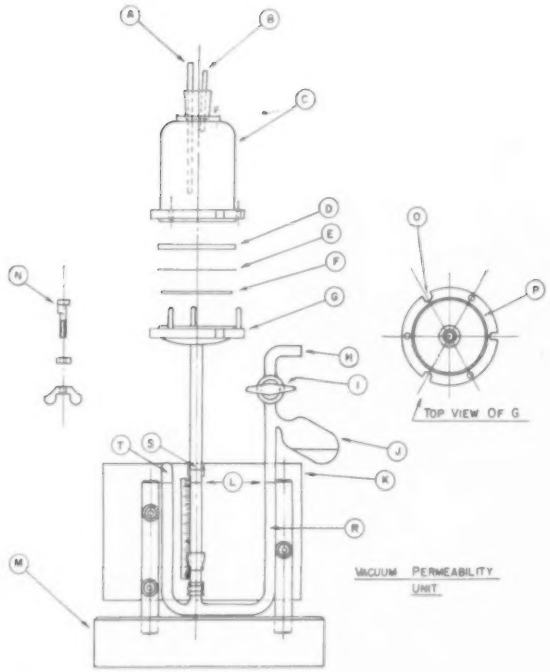

Figure 2

filter paper. The value is measured in milliliters.

T = The temperature in °K at which the test is run.

A = The area of the film sample as measured in square meters.

Two basic assumptions are made in the calculation which are justified for the type of work being reported:

1. The volume (V) is assumed constant. Since the mercury level is dropping, this volume is actually increasing. However, a drop of 20 millimeters in the capillary introduces only a 2% error in the calculation which is within the experimental error of the method.
2. The change in pressure is measured directly from the drop in the level of mercury in the capillary. This disregards any rise in the mercury level in the other two legs of the manometer. This is valid, since the diameter of the capillary is so small compared to the diameter of the other two legs that the rise in these legs is negligible.

These two assumptions together introduce an error of about 3% which falls well within the ± — 10% reproducibility factor of the method.

RESULTS AND DISCUSSION

The permeability apparatus discussed has been used for several months and reproducible results have been obtained on the major flexible film types. All tests reported were conducted at 75° F. and 35% relative humidity.

The data in Table 1 indicate the means and standard deviations of 10 individual readings on two separate samples of polyethylene. Based upon the larger standard deviation (40), the mean of 4 readings on a single sample will be within ± 5% of the true mean 95 times out of 100.

TABLE 1
Air permeability values for 1.5 mil polyethylene

ml/m²/24 hrs.

Test No.	Sample No. 1	Sample No. 2
1	1300	1250
2	1280	1170
3	1280	1200
4	1280	1300
5	1300	1280
6	1300	1250
7	1250	1250
8	1280	1220
9	1250	1250
10	1250	1250
Mean	1277	1237
Standard deviation	21	40

The values in Table 2 show the means and standard deviations from duplicate readings on each of four polyethylene samples. With reference to Table 1, the standard deviation used to obtain the 95% confidence limit was 40. In all four cases shown in Table 2, the standard deviations are below this value.

Table 3 gives the means and standard deviations on each of five individual samples of Saran. Statistical analysis on these data indicate that if five readings are taken on a single film sample, the mean will be within ± 10% of the true mean 90 times out of 100. It is not surprising that the confidence limits on this film are lower than with polyethylene. Since the absolute values for Saran are quite small, any differences between readings would be greatly magnified as compared to the high values for polyethylene.

The data in Table 4 demonstrate the agreement between the values obtained by this method and data obtained on other equipment. When differences in

TABLE 2
Air permeability values for 1.5 mil polyethylene

ml/m²/24 hrs.

	Run No. 1	Run No. 2	Mean	Standard deviation
1	1350	1390	1370	28
2	1330	1310	1320	27
3	1350	1390	1370	28
4	1420	1430	1420	14

TABLE 3
Air permeability values for 2.1 mil Saran

ml/m²/24 hrs.

	Run No. 1	Run No. 2	Mean	Standard deviation
1	1.11	1.32	1.22	0.14
2	1.10	1.28	1.19	0.13
3	1.38	1.11	1.25	0.19
4	1.25	1.38	1.32	0.09
5	1.11	1.25	1.18	0.10

TABLE 4

(ml air/m²/mil/24 hrs.)

	Sarge *(4)*	Dulmage[1]	Olin Film Div.
Saran	2.0	2.3	2.4

Ratio of Permeabilities to that of Saran

	Saran	Mylar	Polyethylene
Stannett & Szwarc *(6)*	1	4	1100
Olin Film Div.	1	5	900

[1] Dow Chemical Corp.

temperature, relative humidity, equipment and operator technique are considered, these data indicate that the apparatus described above yields results equivalent to other methods.

SUMMARY

A simple, inexpensive apparatus for determining the gas permeability of flexible packaging films has been designed. Data is given to show the reproducibility and confidence limits of the method for both high and low permeability films. The ratio of the permeabilities of Saran, Mylar and polyethylene were found equivalent to those published by other investigators. The method is not applicable for exacting research in studies on the theory of gas permeability. It is, however, a simple tool for rating the relative permeabilities of flexible films.

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Notes and Letters

On the Word "Organoleptic"

In a hybrid language such as English technical concepts can be verbalized without recourse to loans from common usage or to the creation of portmanteau words. There are more roots to be remembered, by comparison with a "purer" tongue, but this is offset by gains in precision and, sometimes, elegance.[a] The word "organoleptic," which I take primarily to mean, nowadays, "concerning the sensory impressions associated with eating and drinking" is an interesting example of a neologism that made a false start a century ago and that is having revivalist trouble today. It is worth defending against conservatives and dictionary throwers.

The New Oxford Dictionary (1905) attributes the word *organoleptique* to Michel Chevreul (whose many discoveries included, appropriately enough, the breakdown of flavor into taste and smell), and records that the English equivalent is to be found in Robert Mayne's Lexicon (scientific and medical) of 1857. The Oxford definition refers to "properties by which bodies act upon the senses and bodily organs," i.e. no emphasis is laid on the chemical senses. The Shorter Oxford does not give the word. Webster's New International, 1956, carries over, unchanged from earlier editions, a similar general definition. Most of those technical and medical dictionaries that do list "organoleptic" (and many don't) also fail to mention the specialized use; exceptions are Hackh's *Chemical Dictionary* (Blakiston, 1946), and van Nostrand's *Chemist's Dictionary* (1953), both of which emphasize taste and smell. It is interesting to observe that *Nouveau Larousse Universal*, 1949 edition, has this to say under *organoleptique:* "Se dit de la propriété qui possèdent les corps de faire impression sur les organs de sens, et specialement des propriétés sapides et odorantes, etc. Se dit aussi des substance ou les médicaments qu'on prend par la voie buccale."

In fact I suspect that the word is rare outside the literature of food and taste. It probably began to appear in this literature in the 1930's. My earliest reference is the 1937 May-June issue of Food Research, which was devoted to flavor, and where the word occurs in several places, including the opening review by Crocker and Platt. In the same year, both *Chemical Abstracts* and *Chemisches Zentralblatt*, translating the title of a Ukrainian paper on meat flavor by Smorodinsev *et al.*, used, respectively, "organoleptic" and "-ischen." Thereafter, the word seems to have grown in popularity and then to have fallen from favor in the post-war years. Crocker employed it as a chapter heading in his well-known book *Flavor* (1946) but it does not occur in the text. The manuals of Moncrieff (1951), Piéron (English edition of 1952), and Geldard (1953) do not contain it. Nor is it to be found in the reports of two notable symposia: "Sensory Methods for Measuring Differences in Food Quality" (ed. Dawson and Harris, U. S. D. A., 1951), and "Food Acceptance Testing Methodology" (ed. Peryam, Pilgrim and Peterson, N.A.S.-N.R.C., 1954). It still turns up sporadically in the journals.

At least one eschewer of "organoleptic" argues that Webster's non-recognition of the special sense prohibits that usage. This view lends itself to a *reductio ad absurdum*, inasmuch as its general adoption would petrify the language and put lexicographers out of business! The underlying misapprehension is that a dictionary is a book of rules, whereas in truth it is an unfolding historical record. In this instance a specialized meaning has pushed an older general meaning into limbo. It would be a loss if the word itself, and the noun "organolepsis," were to fall into disuse.

N. T. Gridgeman
Division of Applied Biology
National Research Council
Ottawa, Canada.

September 1956.

Issued as N.R.C. No. 4146.

[a] It is said that Nazi philologists kept urging the embryologists to substitute *Unentwickelteliebensgefrucht* (lit., as-yet-unrolled-fruit-of-love) for the alien *Fetus* . . .

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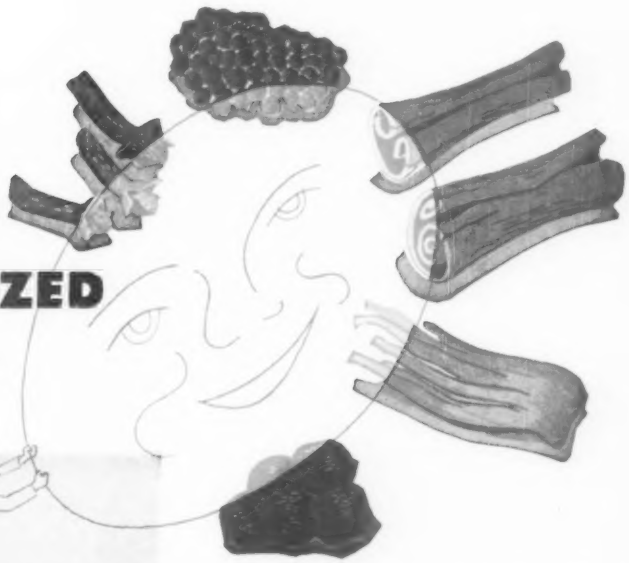

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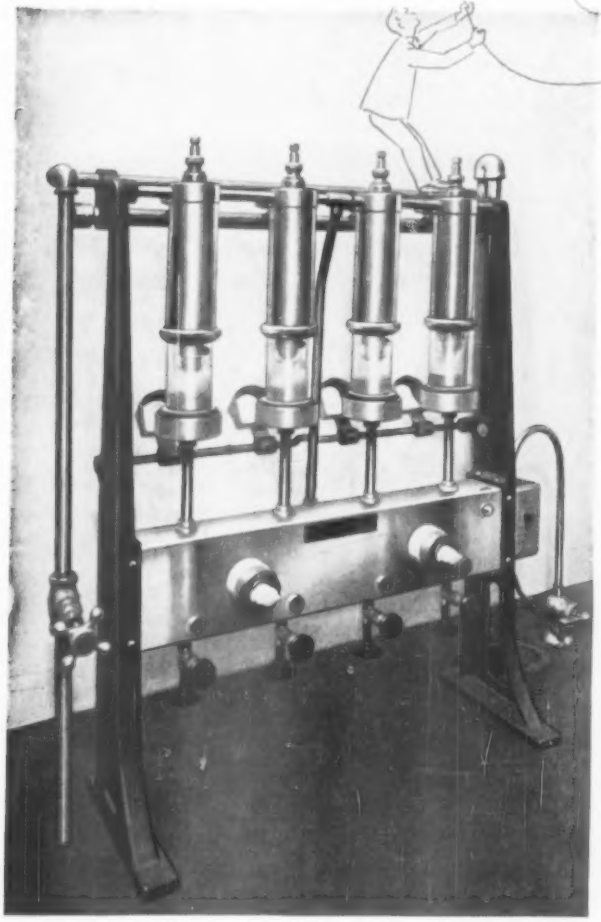

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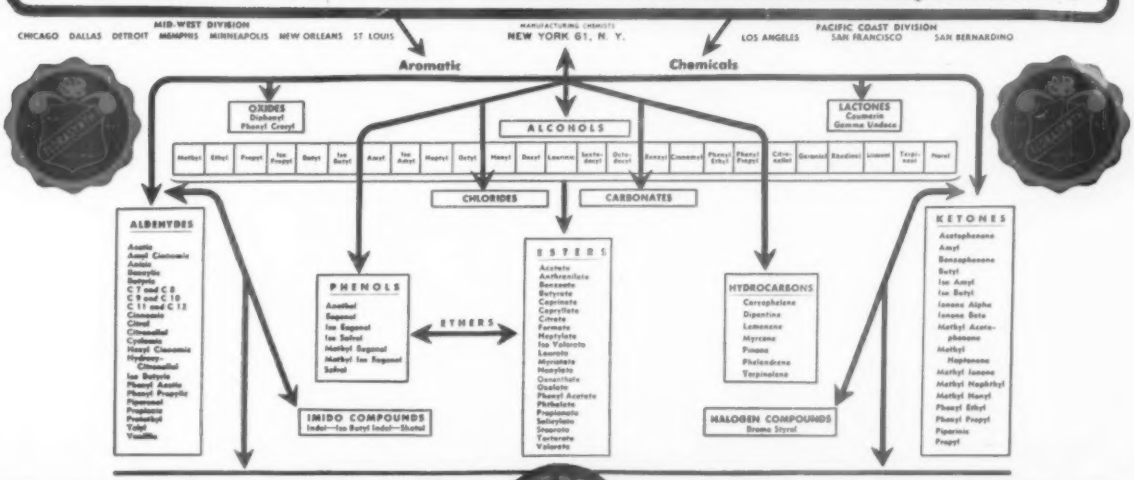

JAN. MAR.

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OCT. DEC.

Year in Year out..

DEPENDABILITY

Florasynth LABORATORIES, INC.

CHICAGO 6 • NEW YORK 62 • LOS ANGELES 21

EXECUTIVE OFFICES:
900 VAN NEST AVE., (BOX 12)
NEW YORK 62, N. Y.

Cincinnati 2 • Detroit • Dallas • Memphis • New Orleans 12
St. Louis 2 • San Francisco • San Bernardino
Florasynth Labs. (Canada Ltd.) • Montreal, Toronto, Vancouver, Winnipeg
Agents & Distributors in Mexico: COMSOLMEX S. A. Mexico 11, D. F.

NIAGARA "NO FROST"

25 Years' Successful Experience

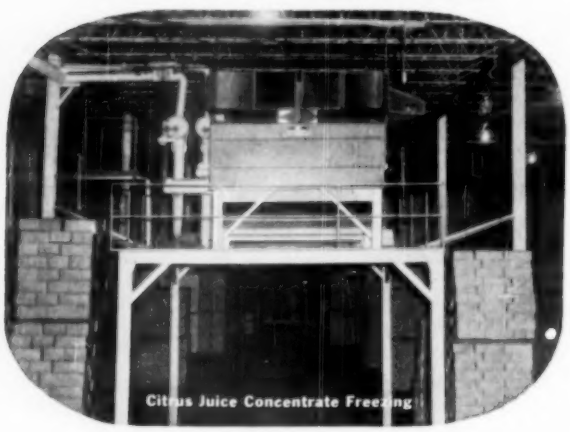
★ *Never any defrosting shutdown*

Citrus Concentrate Freezing and Storage

★ *Never a rise in temperature*

Frozen Food Storage

★ *Save Power . . . Reduce Costs*



Citrus Juice Concentrate Freezing

Write for Niagara Bulletin 105

NIAGARA BLOWER COMPANY

Dept. F. T., 405 Lexington Ave. New York 17, N. Y.

District Engineers in Principal Cities of U. S. and Canada

FOOD INDUSTRY TOPICS

(Continued from page 34 preceding technical papers)

Series" offers the advantage of optimum particle size for most chromatographic requirements. The CG Series is available in four resin classifications: strongly-acidic and weakly-acidic cation exchanger; strongly-basic and weakly-basic anion exchangers. Within each classification the analyst has a choice of two particle sizes: Type I, particle size between 100 and 200 mesh (dry), and Type II, particle size passes 200 mesh (dry).

◆ ◆ ◆

A modern screw-elevator system which has brought major savings to a New York City bakery lifts matzo meal from the second to the sixth floor of the bakery building. It replaced a worn-out pneumatic elevating system. Initial cost of the new system was only a fourth of that of a new pneumatic system, and operating costs with the new system are about half as much as previously. The system was engineered by Fort Worth Steel & Machinery Co., Fort Worth, Texas. For information, write Witherspoon & Associates, 212 Burnet St., Fort Worth 3, Texas.

◆ ◆ ◆

Sol Cafe Mfg. Corp., 180-05 Brinckerhoff Ave., Jamaica 12, N.Y., soon will be marketing **coffee flavors in "squeezable" tubes.** To utilize the tubes, the firm will produce the coffee flavors in jelly or paste form. Tubes of Sol Cafe coffee flavorings probably will come in 8-oz. and 1-lb. and 5-lb. sizes. The tube concentrates also will be available in the various regional blend and roast preferences to which Sol Cafe manufactures its other liquid and frozen concentrates and instant powdered coffee.

◆ ◆ ◆

A new system of flexible hose links combined with quick-connect "snap-on" hose couplings, manufactured by Titeflex, Inc., Springfield, Mass., is one of the features of Dow Corning's new facilities for producing silicone fluids at its Midland, Mich., plant. Using these snap-on flexible hose links in place of multiple-valve installations, conventional fixed pipe lines are run to a central point where the flexible links can be rapidly shifted from one piping line to another, resulting in a switchboard-like arrangement. The patented Quick-Seal coupling manufactured by Titeflex is entirely leakproof at low and high pressure, is free of internal obstructions so as to cause only slight pressure drop in the line, and is practically maintenance-free, requiring only the replacement of seal rings at long intervals.

◆ ◆ ◆

A new 2-stage Colloid Mill has been announced by Manton-Gaulin Mfg. Co., Inc., Industrial Division, 44 Garden St., Everett 49, Mass. It features a special RE (pat. applied for) design incorporating removable rotor, stator, and rotary shaft seal. This is said to simplify operating, speed changeover and cleaning, and to eliminate shaft leakage. The unit has a rotor speed of 10,000 peripheral feet per minute and is designed so that the entire unit can be inspected, cleaned, parts replaced, and reassembled in minutes. The Gaulin 2-stage design also provides a Micrometer Gap Setting which is adjustable while running. This

(Continued on page 42)

Essential Oils
Aromatic Chemicals
Perfume Bases
Flavor Bases
Dry Soluble Seasonings

D&O ESTABLISHED 1798

OUR 158th YEAR OF SERVICE

DODGE & OLCOTT, INC.

180 Varick Street, New York 14, N. Y.

Sales Offices in Principal Cities

"Essentially for you!"

(Continued from page 40)

combination is said to increase processing efficiency and make it readily adaptable for handling all types of raw materials, or for changing quickly from one product to another.

◆ ◆ ◆

Information on its Number 732 Mobile Pressure Sprayer has been released by U. S. Sanitary Specialties Corp., 1001 S. California Ave., Chicago 12, Ill. The new 15-gal. pressure sprayer cart has been designed for use with the firm's Tileze XX cleaning agent and makes it possible to clean large areas with speed and economy. The 732 Sprayer is a compact unit of liquid and pressure tanks mounted on large cart wheels. Operating pressure of 6 pounds is easily maintained by pump lever. The sprayer reportedly will operate for 6 minutes and cover 2,600 sq. ft. of floor area on a single pumping. Tank capacity provides total coverage of 16,500 sq. ft.

. . . *the literary corner*

"The Aerosol Story," 48-page brochure produced by Dodge & Olcott, Inc., 180 Varick St., New York 14, N. Y., traces the industry from its inception in the malaria-laden islands of the South Pacific to its present place of ever-increasing eminence in today's market. All phases of the booming industry, including types and principles, propellents, containers, valves, laboratory tests, labeling, and pre-marketing checks, are discussed. Seven pages of complete aerosol formulations are presented, and the booklet contains an appendix with up-to-date listing of valve and container manufacturers and contract fillers, plus a compilation of miscellaneous suppliers and services. For free copy, write D&O on company letterhead.

◆ ◆ ◆

The first *Supermarket News*, Food Industries Financial Manual, published by Fairchild Publications, Inc., 7 E. 12th St., New York 3, N. Y., contains the year-end financial statements of nearly 300 leading wholesale, retail, and manufacturing firms, and groups these organizations within 18 classifications, including groceries, beverages, dairy items, fish products, fruits and vegetables, meat packing, and paper products. The financial statements cover net sales and profit for the past decade, assets and liabilities broken down for the last two years, and statistical summary. Names of all officers and directors of each organization as well as a listing of subsidiary companies are included. Unfortunately, in this otherwise well-turned-out Manual, the specific areas of responsibility of the various company officers are not listed with the names. The Manual contains 114 pages, is 9″ by 12″ in size, and is bound in hard paper cover. Cost is $10 per copy.

◆ ◆ ◆

A revised 17½″ by 22½″ X-ray Spectrograph Chart showing characteristic secondary X-ray beams for elements from Magnesium (Atomic No. 12) to Californium (Atomic No. 98) is available gratis from the Instruments Division, North American Philips Co., Inc., 750 S. Fulton Ave., Mount Vernon, N. Y. The chart is suitable for wall display and will assist technicians and other personnel to understand the theory and application of X-ray Spectrography. It also will be useful in handling actual problems.

◆ ◆ ◆

"The flavor industry has often been considered a stepchild in the family of modern industries, but it can be established that the grandfather was the spice trade and surely the mother was the perfume industry. This leaves us to assume, by the strong resemblance in characteristics, that the father was none other than pharmacy. Fortunately for the future of the industry, flavors have been 'going steady' with chemistry for half a century." The quotation is from "Flavor Solvents," lead article in the No. 5, 1956, issue of *The Givaudan Flavorist*, published by Givaudan Flavors, Inc., 330 W. 42nd St., New York 36, N. Y.

◆ ◆ ◆

A process for treating eggs and a milk product manufacturing process, both utilizing glycerine, are highlighted in recent patents briefly described in "Glycerine Facts," October 15, 1956, issued by Glycerine Producers' Assn., 295 Madison Ave., New York 17, N. Y.

◆ ◆ ◆

The subject of super cleaning ordinary atmospheric air by means of specially adapted industrial cloth-filter-type dust collectors is treated in Bulletin 557-D, dealing with the Wheelabrator Ultrafiltration process, published by Wheelabrator Corp., 1095 S. Byrkit St., Mishawaka, Ind.

◆ ◆ ◆

The firm's complete line of analytical distillation and vapor-phase chromatographic apparatus are illustrated and described in a folder available from Podbielniak, Inc., 341 E. Ohio St., Chicago 11, Ill.

◆ ◆ ◆

A new 14-page flavor catalog listing essential oils, terpeneless oils, synthetic aromatics, natural and imitation flavors, specialties, etc., has been published by Polak's Frutal Works, Inc., Middletown, N. Y.

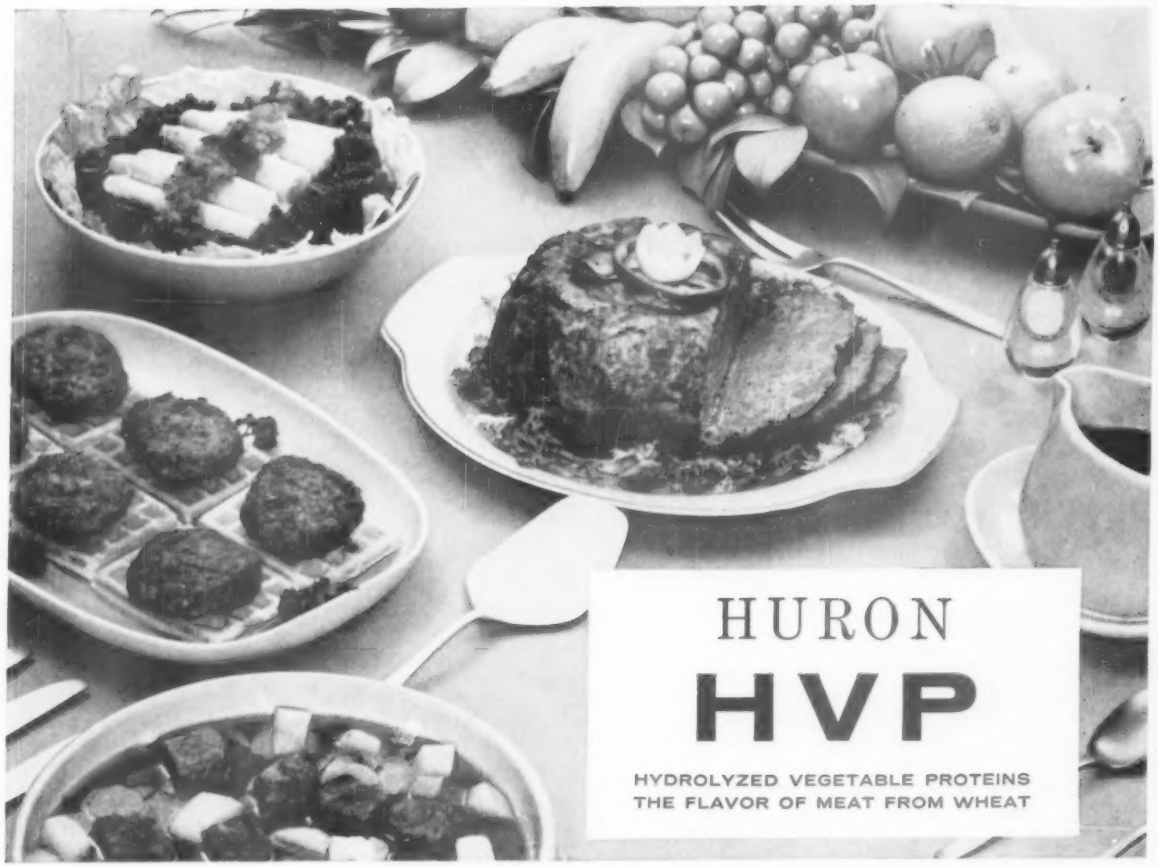
◆ ◆ ◆

More than 5,000 associations, societies, and chambers of commerce are listed in the *Encyclopedia of American Associations*, a business and reference directory, published by Gale Research Co., 424 Book Tower, Detroit 26, Mich., at $15.00. The listing for each association includes address of the national headquarters, executive secretary, number of members and staff, year founded, and a general description briefly outlining membership and purpose of the group. In addition to the basic volume, two additional supplements are included. Supplement I will list new organizations, changes of address, and deletions. Supplement II will list associations by broad subject and functional groupings, such as wholesale associations, retail, womens, veterans, construction, communications, etc.

◆ ◆ ◆

As a help to users of gaskets, shims, and washers, Chicago-Wilcox Mfg. Co., 7701 S. Avalon Ave., Chicago 19, Ill., has released a 28-page catalog illustrating and describing these products in a variety of styles, shapes, and materials. A valuable feature is a

(Continued on page 44)



That good, oven-browned beef flavor *keeps 'em coming back for more!*

Flavors come alive with...

HURON **MSG**

Pure MonoSodium Glutamate 99+%

A taste-maker *and* a sales-maker, Huron MSG intensifies your own fine flavors to bring new taste thrills to processed meats, fowl, fish or seafoods, packaged dinners and other specialties from soups to sausage.

When you boost the taste-appeal of your products with Huron HVP, *your* brand preference and sales climb to new highs! Made from wholesome wheat protein, Huron HVP brings the rich, mouth-watering meatiness of oven-braised beef to canned, frozen and other prepared foods. Huron HVP enables you to control the flavor intensities of your specialty products. Huron offers you a complete line of HVP in liquid, paste, and powder forms. What's more, Huron will send a technical man to work out your flavor problems with you in your own plant. Write today for complete information and samples.

Only one place to get both these taste-builders—

THE HURON MILLING COMPANY

Huron

MSG • HVP • AGE-IT
American Pioneers in Protein Derivatives

Executive Office: 3101 N. WOODWARD AVE., P. O. BOX 9, ROYAL OAK, MICH.
Sales Offices: 9 PARK PLACE, NEW YORK 7 • 161 EAST GRAND AVE., CHICAGO 11 • 383 BRANNAN ST., SAN FRANCISCO 7 • 607 SECOND NATIONAL BLDG., CINCINNATI 2 **Factory:** HARBOR BEACH, MICHIGAN

(Continued from page 42)

complete section listing more than 1500 stock dies available which can often save users the cost of dies in meeting their requirements.

♦ ♦ ♦

A 6-page brochure describing the new "Scotchpak" brand heat-sealable polyester film is available from Minnesota Mining and Mfg. Co., 900 Fauquier St., St. Paul 6, Minn. Emphasized are the heavy-duty packaging and protective wrapping abilities of the film. A table details both physical and chemical properties as well as performance characteristics. The film, which can be heat-sealed with regular sealing equipment to give a seal as strong as the film itself, is available in two forms—"Scotchpak" "A," sealable on one side, and "Scotchpak" "B," sealable on both sides.

♦ ♦ ♦

A 14-page rotary gear pump catalog is available free from Northern Ordnance Inc., Dept. 106, Columbia Heights Station, Minneapolis 3, Minn. The catalog gives complete design, performance, and engineering information regarding Northern Nitralloy Steel Block Pumps as well as general engineering data regarding viscosities and pipe velocities and sizes. Pump sizes range from ¼ g.p.m. to 146 g.p.m.

♦ ♦ ♦

The 40th edition of "Eastman Organic Chemicals," listing more than 3,500 organic chemicals, and including price list, is available on request from Distillation Products Industries, Eastman Organic Chemicals Dept., Rochester 3, N. Y.

♦ ♦ ♦

An article on gas chromatography has been published by Evans Research and Development Corp., 250 E. 43rd St., New York 17, N. Y. Entitled "Hot Air Unlimited," the article is one of a series of "Research Comments" widely distributed to chemical and allied industries. Written by Dr. Donald A. B. Mackay, associate director of research, the article traces the historical background, theory, practice, and potentialities of this important new technique. Copies may be obtained by writing to Dr. Murray Berdick, coordinator of research.

♦ ♦ ♦

The following literature is available from Minneapolis-Honeywell Regulator Co., Industrial Division, Wayne & Windrim Aves., Philadelphia 44, Pa.: Bulletin G-2, an index of Industrial Division literature covering catalogues, bulletins, specification sheets, data sheets, illustrated lectures, and articles from *Instrumentation* magazine; Data Sheet No. 10.2-6, describing the H.E. Sostman & Company transducers which respond to any linear or non-linear function of pressure to position a pen or pointer through a self-balancing bridge circuit; Specification S002-1, describing new moisture-resistant and flexible polyvinyl plastic insulated thermocouple extension wire, available in 14-, 16-, and 20-gauge sizes for use with all types of thermocouples regularly supplied by Honeywell.

♦ ♦ ♦

Reprints of "Facts and Illusions in Resource Development," by Berndt L. Kolker and Melvin R. Levin, staff members of the Industrial Economics Department of Midwest Research Institute, 425 Volker Blvd., Kansas City 10, Mo., are available from MRI.

♦ ♦ ♦

Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio, offers reprints of a 22-page article, "Trends in Industrial Research," written by Dr. Clyde Williams, BMI president. Write M. R. Nestor, manager, project development.

♦ ♦ ♦

"The Outlook for Tomorrow's Grocery Market," an address by Arthur C. Nielsen, president, A. C. Nielsen Company, to the Grocery Manufacturers of America, 76 pages, is available by writing A. C. Nielsen Co., 2101 Howard St., Chicago, Ill.

♦ ♦ ♦

Weldrawn tubing—made by forming cold-rolled strip into tubing, fusion welding the edges, and cold drawing to size—is described in Data Memorandum No. 2, published by Superior Tube Co., 1697 Germantown Ave., Norristown, Pa. Sizes listed in a table of analyses and production limits are from .0625 to 2.500 outside diameter, depending upon the analysis. Standard analyses include 9 types of stainless steels, Monel, Hastelloy "C," Nichrome "V," Beryllium copper, Constantan, 42% nickel iron, 52% nickel iron, and unalloyed titanium.

♦ ♦ ♦

A new pamphlet describing standard pallet shipments of AVISCO cellophane is available from American Viscose Corporation's Film Division, 1617 Pennsylvania Blvd., Philadelphia 3, Pa. The handy pamphlet contains charts of available pallet sizes for roll and sheet cellophane. There is no additional charge for palletizing.

♦ ♦ ♦

"What You Should Know About Bakery Sanitation," recently revised 28-page cleaning guide published by Oakite Products, Inc., 157 Rector St., New York 6, N. Y., discusses up-to-date recommended cleaning procedures for the baking industry and describes the latest in mechanized cleaning equipment.

♦ ♦ ♦

New 16-page booklet TD-507, "Thermal Conductivity Analyzers," full of information on the practical application and operation of these instruments, is offered by Arnold O. Beckman, Inc., 1020 Mission St., South Pasadena, Calif. Originally intended for the manufacturer's own personnel, the booklet is offered free while supply lasts.

♦ ♦ ♦

A 16-page brochure describing its new Model 154-B Vapor Fractometer (gas chromatography instrument) is offered by the Perkin-Elmer Corporation's Instrument Division, Norwalk, Conn. The Model 154-B is operable at higher temperatures than its predecessor, Model 154, has a more sensitive dual thermal conductivity detector, and has, as standard equipment, a solenoid-operated liquid sample collection outlet.

♦ ♦ ♦

Schaar and Co., 754 W. Lexington St., Chicago 7, Ill., announces availability of "Labalog" 956. This new 64-page supplement incorporates a current price list and features many instruments added since publication of the general catalog.

(Continued on page 46)

When shoppers compare your products with other brands...

...CELITE FILTRATION provides perfect clarity... assures appetizing appeal

In today's highly competitive market, it is vitally important that processed food products *look* good as well as *taste* good. For in a shopper's eye clarity is often a measure of purity. That's why so many processors are turning to Celite* diatomite filtration.

By means of a filter cake hundreds of times finer than the finest wire mesh, Celite polishes liquids to a dazzling clarity. And it does it economically, too. Celite is low in cost. It provides practically automatic operation with any standard pressure filter. And you needn't worry about a clarification bottleneck. Celite works at fastest flow rates.

Thousands of processors are using Celite today for filtering sugar, beer, fruit juices and jellies, cooking and salad oils and many other products. Why not ask one of them about Celite. Better still, get the complete story from Johns-Manville.

*Celite is Johns-Manville's registered trade mark for its diatomaceous silica products

When you filter your product with Celite you get the extra sales appeal of sparkling clarity.

Tell us what you make. We'll tell you if and how Celite can help you make it better. Write to Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

JM PRODUCTS **Johns-Manville CELITE FILTER AIDS**

(Continued from page 44)

The "Fluid Agitation Handbook," 46 pages, published by Chemineer, Inc., 1044 E. 1st St., Dayton, Ohio, covers in detail theoretical and practical approaches to fluid mixing problems in the process industries. It outlines step-by-step procedures for determining optimum mixing characteristics of fluids in relation to their physical properties. Since most experimental work in mixing is aimed at selection of standard size plant agitation equipment, methods are given for scaling-up a laboratory mixing operation to a production process. A 46-item bibliography is provided. Price is $1.50, postpaid.

Bulletin 38.1, offered by Askania Regulator Co., 240 E. Ontario St., Chicago 11, Ill., comprehensively explains the Askania Electrojet, an electro-hydraulic unit which creates powerful hydraulic output thrust or torque from low-level electrical input signals, from various sensing elements. Typical applications in position Servos, floating control systems, and other functions are described.

. . . *meeting hall and conference room*

At a recent meeting of the New York Society of Flavor Chemists, retiring President John Bouton of Dodge & Olcott, Inc., was presented with a plaque for his services, and new officers were elected. These are: chairman of the board, John Bouton; president, Chas. Fricke of Polack & Schwartz; vice president, L. Strassburger of van Ameringen-Haebler; treasurer, Jerome Di Genova of Givaudan-Delawanna; secretary, Fred. Schumm of Ungerer & Co.

The Flavor Laboratory of Arthur D. Little, Inc., Cambridge, Mass., inaugurated, on November 19, a series of symposia on flavor research as a part of the firm's 70th anniversary celebration. The first symposium, held in Cambridge, presented a broad picture of the current state of flavor research and its industrial applications. Three other conferences, concerned with laboratory flavor testing, consumer testing, and physicochemical research on flavor are planned for 1957.

Program Chairman C. G. Harrel, director of new product ideas for Pillsbury Mills, Inc., announces a tentative agenda for the 1957 annual meeting of the Research and Development Associates, to be held in Richmond, Va., April 23-25, 1957. The first day's session will include presentations on procurement and inspection procedures and the new Army combat feeding system. Theme of the second day's program will be "Preservation and Packaging." In the afternoon, several symposia will be conducted concurrently. On the final day, a trip will be made to the nearby military installation at Fort Lee. Members and friends of the Associates will be shown the significant phases of work carried on by the three major Quartermaster branches located at Fort Lee—The Quartermaster Board, the QM Field Evaluation Agency, and the QM Training Command. Write Col. R. A. Isker (ret'd.), secretary, R & D Associates, 1819 W. Pershing Rd., Chicago 9, Ill.

Sales relationships, research efficiency, and offshoot gains from research will be featured at the second National Industrial Research Conference to be held at the Conrad Hilton Hotel, Chicago, April 24 and 25, 1957. "Research for Profit" again will be the theme of the conference, sponsored by Armour Research Foundation of Illinois Institute of Technology, Technology Center, Chicago 16, Ill.

. . . *building up and branching out*

Hercules Powder Co., Wilmington, Del., and The Huron Milling Co., Harbor Beach, Mich., have announced a plan for acquisition of Huron Milling by Hercules subject to approval by Huron stockholders. The plan calls for acquisition of all Huron assets by Hercules in exchange for approximately 100,000 shares of Hercules common stock. Huron Milling common stockholders will receive one share of Hercules common stock for approximately three shares of Huron stock. Huron Milling, with more than 500 employes, and net sales last year of nearly $12 million, processes wheat flour into proteins for food supplements, natural food flavoring, and wheat starch. This is the first major expansion by Hercules into a field involving food products, although the firm, which manufactures more than 800 industrial chemicals, has in recent years launched a diversification program into several new fields of chemistry. Hercules plans to operate the Huron business as a division of its Virginia Cellulose Department.

The newly completed addition to Fries & Fries, Inc., 110 E. 70th St., Cincinnati, Ohio, facilities includes this analytical and control laboratory. In charge is Dr. Geo. Bowden, facing, center.

Atlas Powder Company's net earnings in the first 9 months of 1956 were $3,294,608, or $4.40 a common share—a 26% gain over the $2,616,193, or $3.43 a common share earned in the same period last year. Sales and operating revenues from explosives and chemicals totaled $49,999,496 in the first three-quarters of this year. This was an 8% rise over the $46,397,974 reported in the first 9 months of 1955.

The Du Pont Company's Film Department plans substantial expansion of manufacturing capacity for cellophane and "Mylar" polyester film. New facilities to be installed at the Clinton, Iowa, cellophane plant will provide about 10 million pounds additional cellophane capacity by mid-1958. Plans are being readied for addition of another 20 million pounds capacity

(Continued on page 48)

Morton Salt Company's new million dollar laboratory at Woodstock, Illinois, is at the service of the Food Industry to help solve problems relating to the use of salt. For example, here's . . .

How Morton helped pickle packers make a better product

Here's a pickle packer following the Morton procedure for determining the acid and salt content in a pickle brine sample.

Salting pickles correctly—to produce uniform high quality—presents two major problems to pickle packers.

1 Pickle packers (like other canners and food packers) have the problem of using the right amount of salt. The Morton Salt Company helped solve this problem by developing a procedure for testing pickles for *both* acid and salt content.

Morton's testing procedure is fast, accurate, and relatively simple. It includes a glass stirring rod with end point testing colors and contains complete data on when and how to test for acid and salt content.

2 Pickle packers also face the problem of using the right type of salt for better flavor control. Morton helped solve this problem with Morton '999' Salt.

How Morton can help you make a better product

Chances are Morton can help you turn out a better product for less money if you use salt for canning, packing or processing any food product. For Morton makes many grades of salt for the Food Industry, and only Morton has 9 strategically located plants to serve you. We offer fast delivery from a bag to a trainload at favorable prices and freight, *anywhere* in the country.

What's more, one of Morton's Food Technologists can assist you with on-the-spot help with any problem you have pertaining to salt. And he's backed by the services of chemists and salt scientists at Morton's ultra-modern research laboratory.

'999' is a high purity, low cost salt which contains 99.9% clean, pure sodium chloride; exceptionally low in the objectionable trace metals, copper and iron. '999' is an evaporated granulated salt that won't break up in shipment and will dissolve uniformly in an average time of about six minutes (not too fast or too slow). Morton '999' Salt has a practically constant weight per volume and is easily and efficiently dispensed by hand or machine.

☐ Please send me your free testing procedure for determining the acid and salt content of pickle brine.*

☐ I am not a pickle packer but would like more information on how Morton can help me _____

Name _____

Title _____

Company _____

Street _____

City _____ Zone ____ State _____

*Glassware and chemicals necessary for testing pickle salt content may be obtained at a nominal fee from the Natl. Pickle Packers Assn.

MORTON SALT COMPANY
INDUSTRIAL DIVISION
Dept. FT-12 120 So. La Salle Street,
Chicago 3, Illinois

(Continued from page 46)

at other plants shortly thereafter. Expansion in "Mylar" polyester film is to be provided through new construction at the Circleville, Ohio, plant which will increase Du Pont's productive capacity by approximately 50%. This project is scheduled for completion early in 1958. The Circleville plant, which began operations in July 1954, is the first commercial installation for production of "Mylar."

◆ ◆ ◆

Expansion news from American Can Company includes the following: (1) opening of a 240,000,000-metal-containers-a-year capacity plant at Salem, Ore., to supplement output of Canco's Portland factory; (2) purchase of Bradley Container Corp., Maynard, Mass., manufacturer of extruded plastic tubes and bottles and formerly a subsidiary of Olin-Mathieson Chemical Corp., for operation as a wholly owned subsidiary; (3) plans for construction of a third Texas plant, in San Antonio, with a projected capacity of 275,000,000 cans per year. Canco also has announced allocation of $10,000 for its 1956 research grant to the Northwest Laboratory of the National Canners Association in Seattle, bringing to more than $220,000 the amount the company has donated to the Northwest Laboratory since Canco first began to assist the research organization in 1934.

◆ ◆ ◆

Glidden Company officials recently opened a large new Chicago laboratory, the Glidden Foods Research and Service Center, equipped to test all kinds of edible fats and oils and to carry on basic research in these essential foods. The unit, at 2333 Logan Blvd., is operated by the firm's Durkee Famous Foods Division. The new laboratory contains a large central demonstration area around which are grouped the testing and research sections and the library. Each unit is equipped to perform its own research and testing work. The sections are: Basic Research, Customer Formula Development, Control Baking Section, Frying Section, General Baking, Frozen Desserts and Whipped Toppings, Coating Section, Home Economics, and Central Fats and Oils Research. The staff is headed by W. M. Cochran, technical and service director. It is headquarters for Norman Bruce, director of refinery operations for the Durkee Division, and Geo. F. Atkinson, manager of the Chicago refinery.

◆ ◆ ◆

Mrs. Merle Wise of Wise's Super Market, Marion, Ohio, is shown being presented with a $1000 diamond watch by O. J. Osterberg, Akron District Manager of the Diamond Crystal Salt Co., while Mr. Wise and Paul Steckman, Diamond Crystal district representative (right) look on. The radio jingle composed by Mrs. Wise won first prize in the Diamond Crystal Jingle Contest. The theme is based on the current Diamond Crystal advertising approach—"Diamond is a Cook's Best Friend."

◆ ◆ ◆

To meet the increasing demand for trimethylolpropane in the rapidly growing polyurethane plastics and coatings field, Celanese Corporation of America, 180 Madison Ave., New York 16, N. Y., has begun construction of a new polyol production unit at its Chemcel Plant in Bishop, Texas. The plant will utilize special aldoling processes developed by Celanese and will greatly expand capacity for polyol and aldol production which began a year ago with the start-up of a semi-works unit. The new commercial unit is expected to be producing by the end of 1957.

◆ ◆ ◆

Arkell & Smiths, Canajoharie, N. Y., have purchased the bag-making equipment and plates of Thomas Phillips Co., Akron, Ohio, manufacturer of small sugar, salt, and rice pockets, and flour bags and containers. A&S has leased the Thomas Phillips bag factory and will operate this plant in addition to their four bag plants at Canajoharie, Hudson Falls, N. Y., Wellsburg, W. Va., and Mobile, Ala.

◆ ◆ ◆

Sales and net income of Beckman Instruments, Inc., set new records for the fiscal year ended June 30, 1956. Sales were $29,362,131, an increase of 38% over the $21,330,598 recorded in the previous year. Net earnings after taxes amounted to $1,744,856, an

(Continued on page 50)

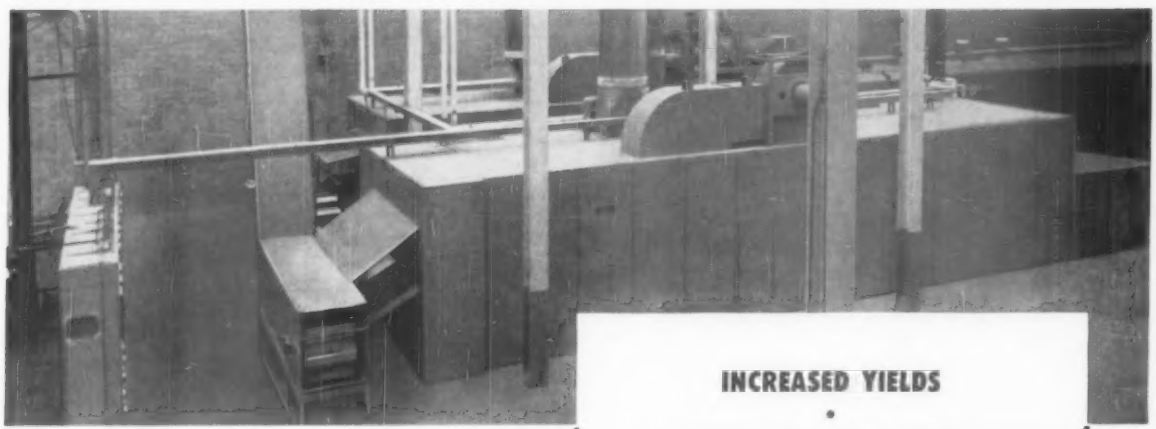
SeaKem "Colloids Out of the Sea"*
unique...
both in their reactivity with proteins and their ability to work well "in combination" with other colloidal materials
*Over 20 distinct types of SeaKem Stabilizers are available . . . each one a highly refined derivative of Irish Moss and standardized for a particular gelling, thickening, suspending or other function.
EXTRACTS
Ask to be put on our mailing list to receive SeaKem® EXTRACTS — the exciting house organ that "tells all" about SeaKem "Colloids Out of the Sea"
Any special application problems? Write today!
Seaplant CHEMICAL CORPORATION
63 David Street, New Bedford, Mass.

Proctor

DRYING RANGES

for

highest product uniformity!



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(Continued from page 48)

increase of 32% over the previous year's earnings of $1,322,050. Expenditures last year for research and development totaled a record $3,114,694, equivalent to 10.6% of sales. The firm is placing special emphasis on data processing and control systems as well as on advanced semiconductor components such as the transistor.

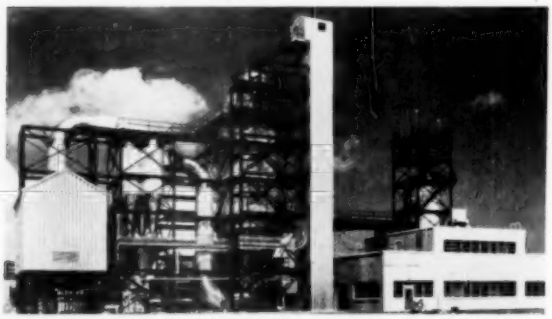
◆ ◆ ◆

Arthur D. Little, Inc., announces opening of a Los Angeles office in the Roosevelt Bldg., Rm. 452, 727 W. 7th St. Dr. Benjamin S. Mesick heads the new office.

◆ ◆ ◆

Formation of Comco Company to act as manufacturers' representatives and brokers in the food and related fields is announced by IFT member D. C. (Clint) Cregier, along with B. J. McAuliffe, L. A. Mackenroth, and C. M. O'Malley. The new firm will headquarter at 8747 St. Louis Ave., Skokie, Ill. Branches in several Midwestern centers will be developed through consolidations with other established representatives.

◆ ◆ ◆



Open construction is a feature of the new spray-drying facility of Corn Products Refining Co., Corpus Christi, Texas, now producing Snow Flake Instant Starch. Brick structure at right houses packaging and heating units. To left of elevator shaft in center is the 88 ft., all stainless steel spray-drying chamber. Duct leading from chamber goes to 4 high-efficiency collecting cyclones which carry the dry starch to the packaging section.

◆ ◆ ◆

General Mills, Inc., 400 Second Ave., S. Minneapolis 1, Minn., has purchased Ready-to-Bake Foods, Inc., Los Angeles, Calif., producer and distributor of "Puffin" refrigerated biscuits, distributed in 34 states. The firm will be operated as a wholly owned subsidiary.

◆ ◆ ◆

A new concept of scientific endeavor was brought to Baltimore in September with the opening of SCIENCE CENTER at a site on N. Bolling Rd., one-half block from U. S. Route 40, just west of the Baltimore City limits. The uniqueness of the plan lies in the housing under one roof of related companies which cover a wide field of scientific activities. Insect Control and Research, Inc., Cornell Chemical and Equipment Co., Inc., and American Bio-Chemical Laboratory, Inc., will share separate but adjacent facilities. These include library and reference rooms, offices, conference rooms, varied laboratory and testing areas, warehouse and service facilities. Dr. Eugene J. Gerberg is president of the venture.

. . . *the human element*

Sheffield Chemical, Norwich, N. Y., announces a change in its sales organization whereby **Frank V. Feorello** becomes sales manager and **F. A. Baldauski** is appointed sales development manager. Mr. Baldauski, a member of IFT, who has been sales and product manager, was formerly technical director of the firm.

◆ ◆ ◆

John L. Cassullo, president of Fritzsche Brothers, Inc., New York City, has announced appointment of **M. J. "Pete" Niles,** manager of the company's Chicago office, to the newly created post of special representative for the president, in which capacity he will undertake key assignments directly related to sales. The firm also announces the retirement, as of January 1, 1957, of **Dr. Edmund H. Hamann,** chief flavor chemist, and a charter and professional member of IFT. Dr. Hamann, who has been with Fritzsche for 29 years, will be retained on a part-time basis as a special consultant.

. . . Fritzsche's Pete Niles

◆ ◆ ◆

Nu Products Co., Inc., 415-39th St., Brooklyn 32, N.Y., manufacturers of food seasonings, flavors, and stabilizers, announce addition to their staff of **Frank Wodar,** a professional member of IFT. Mr. Wodar has been technical director for First Spice Mixing Co., New York City, plant superintendent for Knickerbocker Spice Mills, New York City, and assistant chief chemist for The Sweets Company of America.

◆ ◆ ◆

. . . Foxboro's Wendell S. Young

Wendell S. Young, formerly assistant manager, has been appointed manager of the Food and Lumber Divisions of The Foxboro Co., Foxboro, Mass. He will direct instrument sales promotion activities in these fields, succeeding **Lyle M. Richardson,** a professional member of IFT, who has been named to head the company's new Sales Publications Division. Mr. Young is the author of many papers on instrument applications in the food and lumber industries.

◆ ◆ ◆

Continental Can Co., 100 E. 42nd St., New York 17, N. Y., sends news of these personnel actions: **Peter P. Wojtul,** currently vice president in charge of sales for Continental Can, becomes vice president of the company's Fibre Drum Division, effective January 1, replacing the retiring **Carl E. Eggerss;**

(Continued on page 60)

New Quaker Oats Company Research Center

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Here you see the outside of the John Stuart Research Laboratories just opened by The Quaker Oats Company at Barrington, Illinois. What goes on *inside* you'll discover in the finer quality of all the products you get from Quaker.

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QUAKER

The Quaker Oats Company, Chicago 54, Illinois

SELECTED ABSTRACTS . . .

Compiled by H. A. Campbell

ANALYTICAL METHODS

A rapid method for the determination of total solids in tomatoes.

Mabrouk, A. F., Hussein, A. A., and Aref, H. (Cairo Univ., Giza, Egypt). *J. Sci. Food Agr., 7* (4), 257-61 (1956).

An equation correlating the total solids in raw tomato pulp to its refractive index was formulated. The derived formula for total solids is as follows: Total solids in percentage by wt. = $522.60n_D$-695.26.

The determination of non-fat dry milk solids in bread by paper chromatography.

Zentner, H. (Bread Research Inst. of Australia, North Sydney, N. S. W.). *Analyst, 81*, 483-6 (1956).

A method was devised for the detn. of non-fat dry milk solids in bread. The lactose, which usually comprises 50% of the non-fat dry milk solids, is sepd. from residual maltose in 48 hrs. by descending paper chromatography with an *n*-BuOH-pyridine-H_2O system contg. $AgNO_3$. The optical densities of the Ag spots are then detd. in a densitometer.

BIOLOGICAL SCIENCES

BIOCHEMISTRY

A new pancreatic carboxypeptidase.

Folk, J. E. (U. S. Dept. of Health Education and Welfare, Bethesda, Md.). *J. Am. Chem. Soc., 78* (14), 3541-2 (1956).

The new enzyme is tentatively designated basic carboxypeptidase (BCP) because of its apparent requirement for a basic carboxyl terminal amino acid. Action of BCP as a carboxypeptidase is demonstrated in its failure to hydrolyze benzoylglycyl-L-lysine amide.

The effect of adenosinetriphosphate upon actomyosin solutions, studied with a recording dual beam light-scattering photometer.

Mommaerts, W. F. (Western Reserve Univ., Cleveland, Ohio). *J. Gen. Physiol., 39* (6), 821-30 (1956).

A recording dual beam light-scattering photometer is described which permits kinetic studies involving changes in turbidity, and which is not, as are single photocell instruments, affected by the errors due to the attenuation of the scattered light within the turbid medium. With this method, a renewed study was made of the phys. changes occurring in actomyosin under the influence of ATP.

Carboxymethyl proteins.

Korman, S., and Clarke, H. T. (Columbia Univ., New York). *J. Biol. Chem., 221*, 133-41 (1956).

Bovine serum albumin reacts with bromoacetate at pH 9 to yield derivs. in which the entrant carboxymethyl groups are attached to the amino, phenolic, and imidazole groups. The carboxymethylated protein is insol. in H_2O at pH 2, but sol. at pH 5 and above. It is not coagulable by heat and resembles a denatured protein in the increased chem. accessibility of its disulfide and imidazole groups. Carboxymethylation offers promise as a means for the estn. and identification of terminal α-amino groups in proteins.

A preliminary study of the properties of proteins in some nonaqueous solvents.

Rees, E. D., and Singer, S. J. (Yale Univ., New Haven, Conn.). *Arch. Biochem. Biophys., 63*, 144-59 (1956).

Solubility tests were performed with 23 protein prepns. and Na deoxyribonucleate in 37 nonaq. solvents. Most of the proteins were sol. in hydrazine and ethylenediamine, and other successful solvents, in the order of decreasing effectiveness, were propylenediamine, formamide, dimethyl sulfoxide, ethylene glycol, and N-methylacetamide. Insulin and zein were dissolved in 13 and 15 solvents, resp. with a unique parallelism that suggests some similarity in the structures of the two unrelated proteins. DNA is sol. in hydrazine, ethylene glycol, and formamide. In freshly prepd. hydrazine and ethylenediamine solns., the results of soly., ultracentrifuge, and viscosity expts. indicate that protein mols. are unfolded and elongated compared to their structures in H_2O soln.

The differential, periodic titration of proteins with N/150 potassium-3-tellurate.

Beck, G. (Universitat Bern, Switzerland). *Microchim. Acta*, No. 4-6, 977-8 (1956).

It was shown that in the differential, periodic titration of proteins in sufficient amts. (40 to 60 mg.) the degradation curve proceeds in distinct stages, which probably correspond to very definite peptide linkages.

Structure and composition of soluble feather keratin.

Woodin, A. M. (Inst. of Ophthalmology, Judd St., London). *Biochem. J., 63* (4), 576-81 (1956).

The reaction of sol. feather keratin with 1-fluoro-2: 4-dinitrobenzene and with phenyl *iso*thiocyanate indicates that the protein contains only one-tenth equivalents of N-terminal amino acids/mole of protein. The reaction of sol. feather keratin with carboxypeptidase and with the OH^- ion can be interpreted as evidence for the absence of a molar proportion of α-carboxyl groups. Some of the amino acids in sol. feather keratin were estd. quantitatively. It is concluded that the feather keratin monomer is an unbranched cyclic peptide.

Lipids of wheat flour. I. Characterization of galactosylglycerol components.

Carter, H. E., McCluer, R. H., and Slifer, E. D. (Univ. of Illinois, Urbana). *J. Am. Chem. Soc., 78* (15), 3735-8 (1956).

A benzene ext. of bleached wheat flour was fractionated by Craig distribution between *n*-heptane and 95% MeOH into triglyceride, steroid, lipoprotein and lipocarbohydrate fractions. The lipocarbohydrate was further fractionated from acetone into a more sol. and a less sol. component. In a study of these two materials the carbohydrate moiety of the more sol. fraction was identified as β-D-galactopyranosyl-L-glycerol and the carbohydrate moiety of the less sol. fraction as α-D-galactopyranosyl-1,6-β-D-galactopyranosyl-L-glycerol.

On the biosynthesis of the porphylinlike moiety of vitamin B_{12}.

Shemin, D., Corcoran, J. W., Rosenblum, C., and Miller, I. M. (Coll. of Physicians and Surgeons, Columbia Univ., N. Y.). *Science, 124*, 272 (1956).

Vitamin B_{12} was synthesized microbiologically in the presence of δ-aminolevulinic acid -1,4-C^{14}, sucrose, L-glutamic acid, and salts. On the assumption that 2 moles of aminoketone are utilized for each ring and on the basis of the radioactivity of the vitamin formed, it was concluded that the porphyrinlike structure of the vitamin is synthesized from δ-aminolevulinic acid, as are the porphyrins, and that the mechanism of synthesis of the ring system in the vitamin is similar to that of the porphyrins.

MICROBIOLOGY

Proteolysis by Lactobacillus casei. I. Proteinase activity.

Brandsaeter, E., and Nelson, F. E. (Iowa Agr. Expt. Sta., Ames). *J. Bacteriol., 72* (1), 68-72 (1956).

The activity of the proteinases of *Lactobacillus casei* growing in milk, and of the cell-free ext. of *L. casei* was studied. Maximum activity of the enzymes and their stability were obtained at pH levels somewhat below those found for similar enzymes produced by other bacteria. These proteinases may be an important factor in the protein degradation in Cheddar cheese at approx. pH 5.0.

Desensitization of Escherichia coli to ultraviolet light.

Weatherwax, R. S. (Univ. of California, Berkeley). *J. Bacteriol., 72* (1), 124-5 (1956).

The present report deals with the finding that, in contrast to Kelner's observations with strain B/r, the parent strain B of *Escherichia coli* can be desensitized to ultraviolet light by a prior exposure to light of visible wavelengths.

NUTRITION

Fat absorption in man.

Nutrition Revs., 14, 200-1 (1956).

A study of fat absorption in man conducted with a 22 month old child afflicted with chylothorax. A basal diet was used during most of the test which supplied 28 g. of fat per day and presumably adequate, const. amts. of other nutrients. The type of fat in the diet was changed each week or group of weeks by changing the kind of fat in a protein milk which was used as part of the diet, or given as fat itself. Standard methods were used for detg. satd. and unsatd. fatty acids in the chyle and dietary fat. Changing dietary fat compn. changed chyle fat compn. Distinct differences were noted in the absorption of various fatty acids. 6-, 8- and 10-C fatty acids were seldom found in chyle whereas the 12-, 14-, and 16-C fatty acids were all absorbed to practically the same extent.

Optimum fatty acid ratio in dietary fat.
Nutrition Revs., 14, 221-2 (1956).

Growth rate of 25 male and female rats was studied for 9 weeks on a diet of 20% fat. Fat was prepd. from coconut, corn, and olive oils mixed in such proportions that the desired ratios of fatty acids could be obtained. All diets contained 10% linoleate and diets 1 to 4 (5 was defatted control) contained 70, 60, 30 and 10% satd. fatty acids resp. In male rats, diet 3 (30% satd. to 10% unsatd.) produced significantly greater wt. gains. Later expts. upheld earlier findings. It is evident that the best growth rate resulted from a low ratio of satd. to unsatd. fatty acids.

Dietary fat and the thiamine requirement.
Nutrition Revs., 14, 212-14 (1956).

Studies with humans and rodents support the view that dietary fat reduces the thiamine requirement.

The effects of a low phosphorus ration on calcium metabolism in the rat with the production of calcium citrate urinary calculi.
Spargo, B., and Sager, R. *Proc. Inst. Med. Chicago, 20* (13), 307-8 (1955); *Biol. Abstr., 30* (6), No. 16101 (1956).

Normal Ca low P diet produced calculi in adult male rats after 6 days.

Arsenicals as growth promoters.
Nutrition Revs., 14, 206-9 (1956).

The growth-promoting effect of org. arsenicals appears to be similar to the well-known effect of antibiotics in stimulating animal growth, being most effective in "old" environments. Arsenicals, like antibiotics, do not always stimulate growth in "clean" environments or under all dietary conditions. They apparently are not nutrients but stimulate growth indirectly.

The metabolism of vitamin B_6 in human beings.
Vilter, R. W. (Univ. of Cincinnati, Ohio). *Am. J. Clin. Nutr., 4* (4), 378-83 (1956).

Vitamin B_6 is a very important substance in the diet of adult human beings. Deranged vitamin B_6 metabolism induces lesions in skin, mucous membranes, nerve tissue, and lymphatic system, and the metabolism of tryptophan, protein, carbohydrate, and fatty acids may be affected

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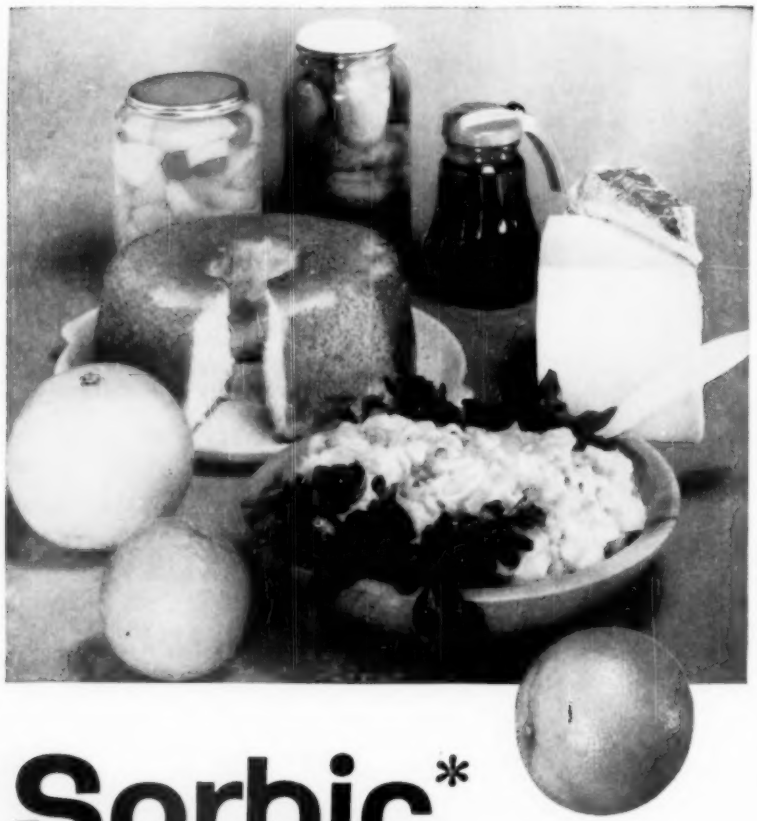

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adversely by this deficiency. In addn., some studies suggest that specific metabolic abnormalities may increase the need for vitamin B_6 and that drugs may cause toxic manifestations by interfering with the function of this vitamin.

Citrate and rickets in rats.
Nutrition Revs., 14, 210-11 (1956).

Results of studies indicate that in expts. with factors affecting bone formation careful attention must be given to Ca, P content of the diet. Thus, citrate may exert a rachitogenic or an antirachitic effect depending on the diet compn. with respect to these two elements. In general it appears that citrate is antirachitic when added to a diet contg. high levels of Ca and contg. P chiefly as phytate.

Mechanism of action of vitamin K.
Nutrition Revs., 14, 211-12 (1956).

Authors have reported a series of expts. confirming and extending their previous results that the mode of action of vitamin K is as part of an enzyme system concerned with the "coupling" of oxidation and phosphorylation. The authors conclude that menadione should be classified as a provitamin to which a phytyl chain could be added in the animal body. The actual vitamin K action must reside in the nucleus while the side chain acts as a carrier binding it to lipoprotein for transport to the site of action.

Some studies of tocopherol in infants and children.
GORDON, H. H., AND NITOWSKY, H. M. (Johns Hopkins Univ. Sch. of Med., Md.). *Am. J. Clin. Nutr., 4* (4), 391-6 (1956).

Studies of hemolysis and plasma tocopherol indicate that newly born full-term and premature infants have a deficiency of tocopherol. In the former, it is remedied quickly by breast feeding and less consistently by feeding whole cow's milk mixts., but in the latter it persists on customary feeding mixts. of partially skimmed cow's milk. Because of their defect in fat absorption and the limited tocopherol content of both whole cow's milk mixts. and stored human milk, supplementation of the diets of premature infants may be necessary to repair the deficiency. One might est. daily supplementation at 0.5 mg./kg. body weight. The authors are, however, reluctant to make such a recommendation.

Inositol biosynthesis.
Nutrition Revs., 14, 219-20 (1956).

Results of several studies on the biosynthesis of inositol indicate that inositol is not a dietary essential for the rat. The requirement of inositol for various body functions appears to be met by tissue biosynthesis. It would appear that from a dietary standpoint inositol should not be considered a vitamin for higher animals in the usual sense of the word.

The effects of oral estrogens and androgens singly and in combination on yearling steers.
BEESON, W. M., ANDREWS, F. N., STOB, M., AND PERRY, T. W. (Purdue Univ. Agr. Expt. Sta., Lafayette, Ind.). *J. Animal Sci., 15* (3), 679-84 (1956).

(Continued on page 56)

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(Continued from page 54)

The feeding of 10 mg. of diethylstilbestrol or a combination of 5 mg. of diethylstilbestrol and 50 mg. of Me testosterone to fattening yearling steers resulted in a 12% increase in growth rate over a 179-day trial. Stilbestrol-fed steers required 18% less feed per unit of gain during the first 98 days of the trial and 5% more feed per unit of gain during the last 81 days than the control lot which received no hormone. Steers fed no hormone dressed significantly higher than steers fed diethylstilbestrol, whereas steers fed a combination of stilbestrol and testosterone dressed significantly higher than the steers fed stilbestrol or steers fed with either testosterone alone or no hormone. The carcasses from the hormone-fed steers were slightly inferior, according to Federal Grading Standards, to carcasses from steers which had not received hormones.

The effect of age and plane of nutrition on growth hormone and thyrotropic hormone content of pituitary glands of Holstein heifers.

ARMSTRONG, D. T., AND HANSEL, W. (Cornell Univ., Ithaca, New York). *J. Animal Sci., 15* (3), 640-9 (1956).

Bioassays were carried out on anterior pituitaries of Holstein heifers raised on 3 levels of nutrition and slaughtered at 6 different ages to det. their growth hormone and thyrotropic hormone contents. The results indicated that the quantities of growth hormone and thyrotropin detected in pituitary assays are fairly close approximations of the actual rates of secretion of these hormones by the pituitary. They suggest that differences in rates of growth of heifers at different ages are at least partly due to differences in amts. of pituitary growth hormone and thyrotropin being produced. However, differences in growth rates of heifers on different feeding levels were due to differences in amts. of nutrients available for growth, rather than to any differences in hormone production by the pituitary.

Antibiotic concentration in eggs from hens on chlortetracycline supplemented diets.

RAICA, N., HEYWANG, W., AND KEMMERER, A. R. (U.S.D.A., Animal and Poultry Husbandry Research Branch, Glendale, Arizona). *Poultry Sci., 35* (4), 884-8 (1956).

Laying hens, approx. one year old, were fed chlortetracycline at levels of 50, 100, 200, 500, 1,000, and 2,000 g./ton. No antibiotic was detected in the eggs from hens fed chlortetracycline at the 50-200 g./ton levels. Amts varying from 0.018-0.141 mv./g. of egg were found in the 50-200 g./ton levels. All eggs became negative during the first week after removal of chlortetracycline from the diet.

The "Rockefeller diet."

COUNCIL ON FOODS AND NUTRITION. *J. Am. Med Assoc., 161* (17), 1636 (1956).

This article points out that the diet, minus the data, has been popularized by persons other than the original authors. It emphasizes the fact that the exptl. character of such an abnormal diet makes it imperative for the physician to recommend its use only after careful investigation.

Low-protein diets for reducing.

JOLLIFFE, N. (Bureau of Nutrition, Dept. of Health, New York City). *J. Am. Med. Assoc., 161* (17), 1633-6 (1956).

A critique of low-protein diets, emphasizing the hazards involved.

Food intake of nursery school children at noon.

MIRONE, L., TORRANCE, V. F., AND ROUGHTON, C. W. (Univ. of Georgia, Athens). *J. Am. Dietet. Assoc., 32* (8), 707-9 (1956).

The quantity of foods consumed at the noon meal by preschool children, 3 years 10.5 months of age, is discussed. With the exception of Irish and sweet potatoes, vegetables were consumed in the least amts. and desserts in the largest amts. About one-third as much liver was consumed as beef. The girls drank 102.3 g. milk as compared with 88.2 g. for the boys. Sex, day of week, and week order had no significant effect on the quantity of food ingested during the noon meal.

Integration of current views on the regulation of hunger and appetite.

GROSSMAN, M. I. (U. S. Army Med. Nutrition Lab., Denver, Colo.). *Ann. N. Y. Acad. Sci., 63* (1), 76-91 (1955); *Biol. Abstr., 30* (9), No. 25483 (1956).

These major points are considered: Hunger and appetite are psychic correlatives of the bodily processes which regulate nutrient balance. They arise from and participate in, the regulatory processes. Food-taking is a motor act of skeletal muscles, governed by nervous processes like all other voluntary muscles. Specialized hypothalamic areas participating in this control were discovered. Among the factors which may regulate activity of these hypothalamic centers and of other brain areas concerned with feeding are oropharyngeal stimulation, gastrointestinal distention, blood levels of nutrients (particularly glucose), and tissue stores of nutrients. For none of these factors is the mechanism of action known.

PHARMACOLOGY AND TOXICOLOGY

Halogenated acetic acids.

Assoc. Food & Drug Officials, U. S., 20 (3), 135-7 (1956).

Monochloro-, monobromo-, and monoiodoacetic acids are poisons to the enzyme systems in the body which have to do with the storage and release of energy derived from foods. Any interference of this process, no matter how small, must be considered a hazard to health.

Rational approaches to drug structure.

BURGER, A. (Univ. of Virginia, Charlottesville, Va.). *J. Chem. Educ., 33* (8), 362-72 (1956).

Some important facets of the present knowledge of transport *in vivo* and mechanisms of drug action are summarized.

PHYSIOLOGY AND MEDICINE

Vitamin B_{12} serum level and pregnancy.

OKUDA, K., HELLIGER, A. E., AND CHOW, B. F. (Johns Hopkins Hosp., Baltimore, Md.). *Am. J. Clin. Nutr., 4* (4), 440-2 (1956).

Vitamin B_{12} serum levels of mother and fetus were detd. in 25 women ranging in age from 15 to 41 years, and in their first to ninth pregnancy. It was found that the vitamin B_{12} serum level of the maternal blood was considerably lower than that of the nonpregnant women of comparable age, and also lower than that of the fetal cord level. These findings may indicate that vitamin B_{12} is drawn from the mother to the fetus.

Stannous fluoride and tooth decay.

Nutrition Revs., 14, 197-200 (1956).

Data from 3 preliminary studies suggest that SnF_2 may be an effective aid in reducing the incidence of dental caries. SnF_2 appears to be more effective than NaF in caries reduction.

Role of ascorbic acid in infections.

Nutrition Revs., 14, 214-15 (1956).

Four possibilities of the mechanism of ascorbic acid action against bacterial infection are enumerated: 1. direct antibacterial properties once it is in the blood, 2. presence of a reducing agent in the blood may be effective in protecting other vitamins or essential substances from oxidation, 3. antioxidants may be necessary to facilitate specific enzyme reductions entering into the resistance of the host to invading organisms, 4. antioxidants may act in nonspecific detoxification.

ENGINEERING AND PLANT EQUIPMENT

The transport and handling of liquefied gases.

EASTLAND, D. H. (British Oxygen Co. Ltd., Engl.). *Brit. Chem. Eng., 1*, 244-50 (1956).

The article describes some of the more recent techniques and equipment involved in the transport and handling of liquefied gases.

Planning for safety.

MALLICK, R. W. (Westinghouse Electric Corp., East Pittsburgh, Pa.). *Mech. Eng., 78* (9), 815-19 (1956).

Important plant-layout safety principles and features in industrial plants and the plant-layout engineer's opportunity to provide for the future safety of plant personnel are presented. The paper also discusses the following: the plant site, entrance and exits, aisles, stairs, elevators, ramps, floors, and obstructions, equipment arrangement and guarding, painting and lighting, fire and explosion prevention, first aid facilities, flow of materials and good housekeeping, and materials handling and storage.

FOOD AND FOOD TECHNOLOGY

CEREALS AND GRAINS

Nutritional improvement of rice.

KIK, M. C. (Univ. of Arkansas, Fayetteville). *J. Am. Dietet. Assoc., 32* (7), 647-50 (1956).

The proteins of whole and milled rice were improved by the addn. of lysine, threonine, and vitamin B_{12} and those of enriched milled rice by the addn. of lysine and threonine. Data are presented on the content of amino acids (essential and nonessential), vitamins, and other constituents of whole rice and perch. The proteins of perch had a supplementary value for those of milled rice.

The soluble polyglucose of sweet corn (zea mays).

PEAT, S., WHELAN, W. J., AND TURVEY, J. R. (Univ. College of North Wales, Bangor). *J. Chem. Soc.*, 2317-22 (1956).

Two H_2O-sol. polyglucoses of sweet corn (var. Golden Bantam) have been investigated. Evidence shows each to have the characteristics of a glycogen rather than of a starch. Extensive amylolytic degradation occurs during the aq. extn. of the grain. When enzyme action is inhibited by Hg^{++} during extn. no degradation products of starch or glycogen are found.

COFFEE AND COFFEE PRODUCTS

Role of caffeine in relief of headaches.

SCHWEISHEIMER, W. *Tea & Coffee Trade J., 110* (6), 24+ (1956).

Coffee was found effective in combating fatigue. Caffeine compd. was found most effective remedy for migraine.

FATS AND OILS

The fractionation of marine-oil fatty acids with urea.

DOMART, C., MIYAUCHI, D. T., AND SUMERWELL, W. N. (Technol. Lab., Seattle, Wash.). *J. Am. Oil Chemists' Soc., 32* (9), 481-3 (1955).

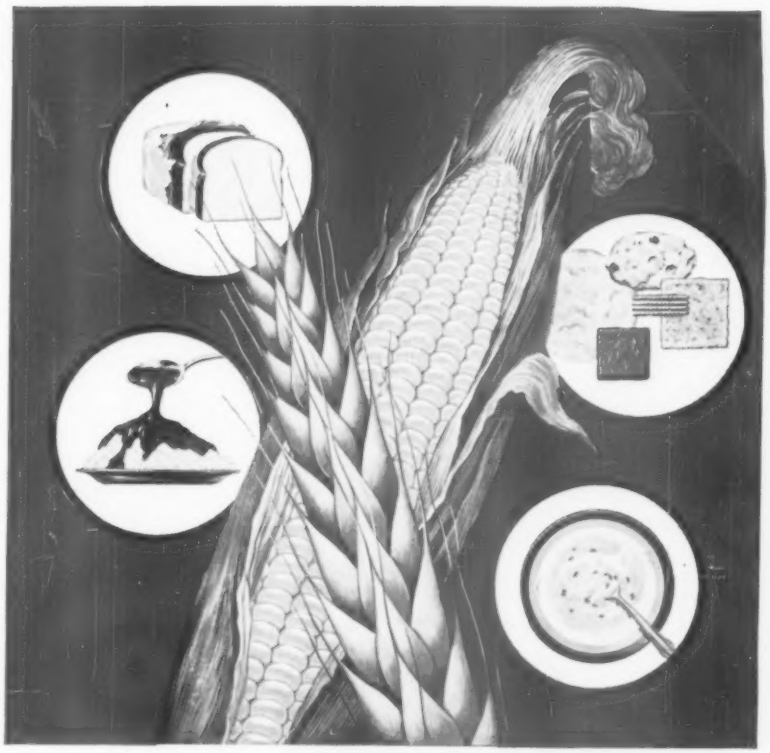
Oils obtained from marine animals are characterized by their substantial content of long chain fatty acids having 20 to 24 C atoms and 3 to 6 double bonds. Such oils also contain abundant amts. of the shorter chain, more satd. fatty acids. This broad mixt. of satd. and unsatd. fatty acids in marine oils makes necessary a preliminary sepn. before the oils can be used for some purposes, particularly those requiring good drying properties. Urea forms cryst. complexes with satd. and monoolefinic fatty acids. The present report describes the prepn. and properties of fatty acid fractions obtained by applying urea crystn. to the fatty acids prepd. from a number of common marine oils.

FEEDSTUFFS

The loss of carotene from dried green crop during storage. The gradient of loss through a stack.

BOOTH, V. H. (Dunn Nutritional Lab., Milton Road, Cambridge, Engl.). *J. Sci. Food Agr., 7* (2), 114-19 (1956).

Considerably more carotene was lost from the middle of a com. type stack of dry lucerne meal than from the edges.



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Part of the increased loss in the center was due to the higher temp. there. The major part of the difference in the rates of loss was due to the protective effect of moisture taken up from the air at the outer surfaces of the stack.

POTATOES

Discoloration of machine-peeled potatoes.

LONGREE, K. (Cornell Univ., Ithaca, New York). *J. Am. Dietet. Assoc., 32* (7), 639-43 (1956).

A surface discoloration of potatoes, enzymatic in nature, is being observed in machine-peeled potatoes when they are held in H_2O prior to cooking. Variety of potatoes used had a significant effect on surface coloration of machine-peeled potatoes. In a 3 year trial, tubers of Bliss Triumph variety did not discolor while Ontarios discolored most severely. Discoloration was increased after a storage period of 3 months. Hand-peeled potatoes of the ten varieties studied did not discolor. Of the three mechanical peelers tested, a peeler in which the potatoes were abraded while floating in H_2O did not seem to bruise the tubers of the variety Ontario sufficiently to bring about discoloration.

Accelerated storage tests for dehydrated vegetables.

GOODING, E. G. B., AND DUCKWORTH, R. B. (Exptl. Factory, Greyhope Road, Aberdeen, Scotland). *Nature, 177*, 897-8 (1956).

Results are presented in support of the thesis that browning developed in dehydrated potatoes during storage for a certain no. of days at 55° C. is approx. equal to that developed in the same no. of mos. at 37° C.

TASTE AND TASE TESTING

Panel testing for flavors.

FOURMAN, V. G. (Syntomatic Corp.). *Am. Perfumer & Aromatics, 67* (5), 62-70 (1956).

The author discusses how to select a panel to assure satisfactory results, factors that must be considered, techniques to be used, tasting pharmaceuticals for flavor and consumer panel testings.

PHYSICAL RESEARCH

The viscosity of liquids.

BRANDT, W. W. (Polytechnic Inst. of Brooklyn). *Dissertation Abstr., 16* (6), 1071 (1956).

The development of a workable method for calcg. viscosity which is both practical and based on sound assumptions.

Electrostatic particle size analyzer.

YOSHIKAWA, H. H., SWARTZ, G. A., MACWATERS, J. T., AND FITE, W. L. (Univ. of Pennsylvania, Phila.). *Rev. Sci. Instr., 27* (6), 359-62 (1956).

This paper comprises the theoretical analysis and phys. description of an Electrostatic Particle Size Analyzer (EPSA) for detg. the particle size distribution of aerosols in the 1- to 20-micron size range. Included are photographs and histograms illustrating the size sepn. attained and also a histogram of the particle size distribution in the general aerosol as detd. by use of the instrument.

Studies on the effects of treatment with chlorine dioxide on the properties of wheat flour. IV. The biological properties of untreated, normally treated and overtreated flours.

FRAZER, A. C., HICKMAN, J. R., SAMMONS, H. G., AND SHARRATT, M. (Univ. of Birmingham, Engl.). *J. Sci. Food Agr., 7* (7), 464-9 (1956).

General health and survival, body wt. gain, fertility and no. of offspring, birth wt. and wt. gain during lactation, histopathological appearances and relative wt. of the main organs were studied over three generations in groups of rats receiving 56.8% of the diet in the form of flour. The flour supplied to the different groups was either untreated, or treated at normal level, or ten times normal level, with ClO_2. There was no indication in any of these expts. that the treatment or over-treatment of the flour with ClO_2 caused any deleterious effects in these animals. From this and previously published evidence, it is concluded that ClO_2 treatment does not significantly affect the nutritional value of flour for human subjects.

POLYMER RESEARCH

New kinds of macromolecules.

BAWN, C. E. H. *Endeavour, 15* (59), 137-43 (1956).

The past twenty-five years has seen immense progress in our understanding of the nature of macromolecules and in the development of general methods of synthesis. Recent research has led to the development of new synthetic methods which yield macromolecules of types not previously known and possessing combinations of properties indicating a wide range of practical applications for them. These developments have opened a new chapter in the stereochem. of the polymer mol., which from both the theoretical and practical points of view is of immense significance.

RADIOCHEMICAL TECHNOLOGY

Symposium on the use of radioactive materials in biological assay.

Analyst, 81, 433-40 (1956).

The following papers and discussions are summarized: The principles of isotope-dilution assay with special reference to vitamin B_{12}. The detn. of radioactive isotopes in biol. samples. Bioassay of radio-iodinated plasma proteins for clinical use. Isotope-dilution assay of antibiotics in fermentation liquors with particular reference to benzylpenicillin and griseofulvin. The assay of aldosterone and other adrenal steroids by the $^{24}Na/^{42}K$ method. Labelled metabolic pools for studying quantitatively the biochemistry of toxic action.

STATISTICS

Fundamentals of analyses of variance. Part I. The analysis of variance (ANOVA) model.

HICKS, C. R. (Purdue Univ., West Lafayette, Ind.). *Ind. Quality Control, 13* (2), 17-20 (1956).

A simplified presentation is given of the technique for using the analysis of variance, including assumption, calcns. and interpretation.

Competent, scheduled instrument maintenance service at Schroeder Products Co. Inc., major producer of coffee concentrates at Woburn, Mass Gordon Andrews, shown here, typifies the factory-trained Foxboro Service Technicians serving the industry from nearby engineering offices.

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SCHEDULED MAINTENANCE SERVICE

(Continued form page 50)

B. J. Kearney has been appointed general manager of the Research and Development Department for the Paper Container Division, following service as Continental's acting research and development director; **Howard G. Lewis,** executive vice president of Hazel-Atlas Glass Company prior to that firm's recent merger with Continental Can, has been elected a vice president of Continental, in charge of the Hazel-Atlas Glass Division.

◆ ◆ ◆

Two internationally distinguished scholars, **Dr. and Mrs. Chas. Singer** of London, England, have been awarded the second annual George Sarton Medal for their contributions to science history by the History of Science Society. The medal was named for the late George Sarton, Harvard professor emeritus of the history of science, who received the first award last year. It was made possible by a grant of $1,500 from Chas. Pfizer & Co., Inc.

◆ ◆ ◆

Dr. Herbert Trotter, Jr., vice president of engineering and research for The Sharples Corp., Philadelphia, has been named executive vice president. Since joining Sharples in February 1956 (from Eastman-Kodak Naval Ordnance Division), he has headed the research in and development of centrifuges and centrifugal processes of the company, as well as powder classification and other projects of the Sharples Research Laboratories.

◆ ◆ ◆

Vern I. McCarthy, Jr., (right), vice president of Vulcan Containers Inc., Bellwood, Ill., manufacturers of steel shipping containers and tin cans, is shown being sworn in for his six-month's assignment with the Business and Defense Services Administration by Chas. F. Honeywell (left), Administrator of the BDSA. Mr. McCarthy will represent the entire American packaging and container industry in his capacity as Deputy Director of the Containers and Packaging Division of BDSA.

◆ ◆ ◆

Billy Kan, a member of IFT, who recently completed the requirements for a Ph.D. in food technology at MIT, has joined the staff of Continental Can Company's Metal Division, Research and Development Department, 1350 W. 76th St., Chicago, as a research engineer.

◆ ◆ ◆

Vincent N. DeCerchio has been named assistant to the president of Orr & Sembower, Inc., Reading, Pa., manufacturer of heat transfer equipment. His general duties will be in the handling of government work.

◆ ◆ ◆

Appointment of **Dr. J. S. Barton** as director, Packaging Research & Development, was announced by Western-Waxide Specialty Packaging Division, Crown Zellerbach Corp., San Leandro, Calif. A graduate of the University of Washington and the Institute of Paper Chemistry, Appleton, Wis., Dr. Barton formerly was manager of Paper Research in Crown Zellerbach's Central Research Department, Camas, Wash.

. . . Barton of Crown Zellerbach

◆ ◆ ◆

After almost half a century of service in the candy industry, **Harold S. Clark** retired from active management of D. L. Clark Candy Company on November 1. However, he will serve as consultant and advisor to the president and executive vice president of Beatrice Foods Co., Chicago, on matters pertaining to the candy industry. The Clark Candy Company, which Mr. Clark will continue to serve as a director, joined Beatrice Foods in October 1955.

(Continued on page 63)

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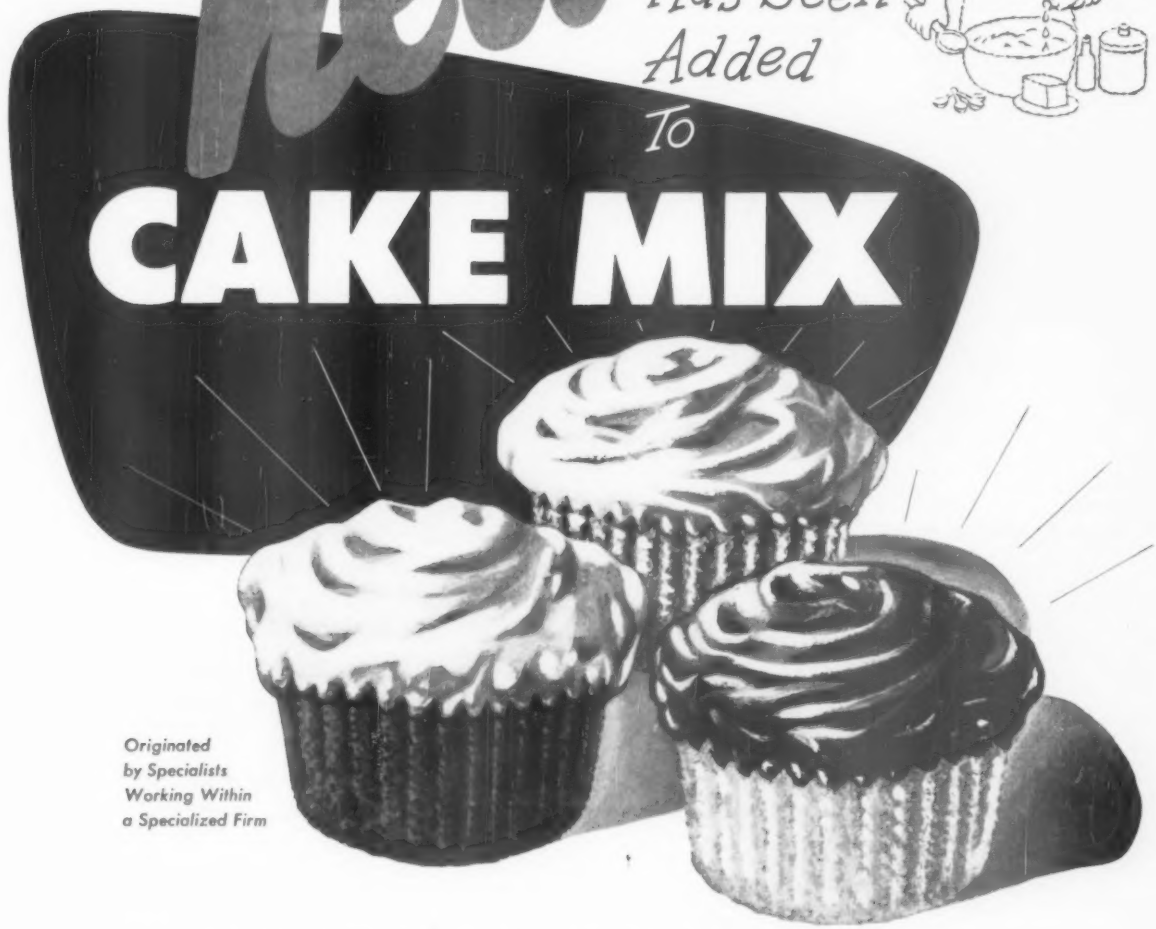

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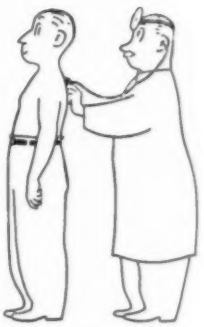
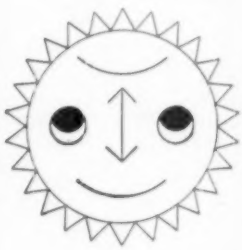
See your doctor *every year* for a thorough checkup, no matter how well you may feel.

day-to-day policy:

See your doctor *immediately* at the first sign of any of the seven danger signals that may mean cancer.



About 1 in 4 of us living today will develop cancer at some time in our lives.

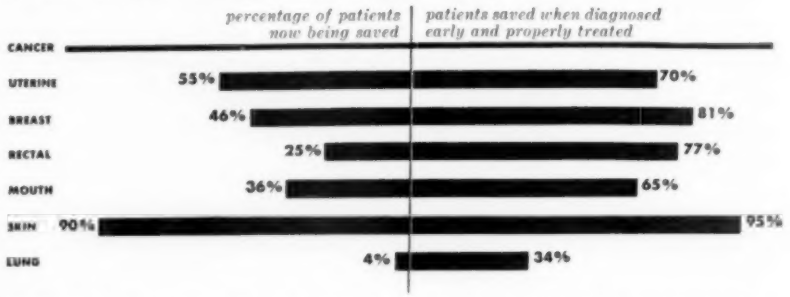


LET'S LOOK AT THE BRIGHTER SIDE

Cancer is much more curable than it was even 10 years ago. Approximately 150,000 Americans are being saved every year.

More and more people are going to their doctors *in time*. In fact, today one out of every three cancer patients is being saved annually. Formerly only one out of four was saved. This amounts to an additional 30,000 lives saved every year.

MANY MORE THOUSANDS COULD BE SAVED



(Estimates based on reports to the Third National Cancer Conference that included comprehensive data from the Connecticut State Department of Health, as well as the records of many hospitals, clinics, and other medical sources. The figures are believed to be sound estimates for most of the United States).

7 "LIFE-SAVING" SIGNALS

These seven so-called "danger" signals of cancer have, in reality, been seven *life-saving* signals to hundreds of thousands of Americans who have gone to their doctors at the first sign of any one of these:

1. ANY SORE THAT DOES NOT HEAL
2. A LUMP OR THICKENING IN THE BREAST OR ELSEWHERE
3. UNUSUAL BLEEDING OR DISCHARGE
4. ANY CHANGE IN A WART OR MOLE
5. PERSISTENT INDIGESTION OR DIFFICULTY IN SWALLOWING
6. PERSISTENT HOARSENESS OR COUGH
7. ANY CHANGE IN NORMAL BOWEL HABITS

None is a *sure* sign of cancer, but only a doctor can tell.

AMERICAN CANCER SOCIETY

FOR MORE LIFE-SAVING FACTS ABOUT CANCER CALL THE AMERICAN CANCER SOCIETY OR WRITE TO "CANCER" IN CARE OF YOUR LOCAL POST OFFICE.

(Continued from page 60)

Appointment of **Miss Joy Rasmussen,** formerly assistant professor of foods and nutrition at the University of Georgia, as director of home economics of the Kroger Food Foundation in Cincinnati has been announced by Geo. F. Garnatz, director of the Foundation. In her new position, she will be known professionally as "Jean Allen." At the Food Foundation, the home economics department kitchen-tests Kroger food products, develops recipes for the firm's packaged goods, and provides information for homemakers. Members of the home economics staff also assist with Kroger's Consumer Information Program.

◆ ◆ ◆

. . . FMC's Tom Martin

Appointment of **Thomas N. Martin** as eastern sales manager of Food Machinery and Chemical Corp., Canning Machinery Division, was announced by Dr. Harold L. Link, manager of the firm's Eastern Operation at Hoopeston, Ill. In his new capacity, Mr. Martin is responsible for the CMD sales activities in all excepting the 11 Pacific Slope States, Florida, and Lower Texas. He will maintain his headquarters in Hoopeston.

◆ ◆ ◆

. . . Staley's Doxsie

L. E. Doxsie has been appointed assistant manager of the Corn Division of A. E. Staley Mfg. Co., Decatur, Ill., processors of corn and soybeans. Materials and methods superintendent since 1953, he has been with the firm for 23 years. He has served progressively as division and production superintendent.

◆ ◆ ◆

Dr. Stefan J. Robock, noted economist and authority on regional development, has been named manager of the Industrial Economics Division of Midwest Research Institute, 425 Volker Blvd., Kansas City 10, Mo.

◆ ◆ ◆

Stanley A. Greenwell has been appointed midwest district manager of the Girdler Company's Votator Division, with headquarters at the Board of Trade Bldg., 141 W. Jackson Blvd., Chicago. The Girdler Co., Louisville, Ky., is a division of National Cylinder Gas Co., Chicago.

◆ ◆ ◆

The Dodge & Olcott, Inc., Achievement Award, consisting of a gold medallion and a check for $1,000, given annually for outstanding contribution to the growth and general welfare of the meat packing industry, was awarded, posthumously, to **Dr. Henry Reist Kraybill,** vice president of the American Meat Institute Foundation, Chicago, who passed away on September 30. Work carried out under the direction of Dr. Kraybill and his associates, **Dr. L. R. Dugan** and **Dr. B. W. Beadle,** on the use of butylated hydroxyanisole and butylated hydroxytoluene has permitted protection of animal fats and foods made from fats from oxidative rancidity.

◆ ◆ ◆

Richard Fiske Shaffer has been retained as a chemical consultant by Gifford-Wood Co., Hudson, N. Y. He will be concerned chiefly with product development and application of the firm's line of chemical processing equipment. These include the G-W line of Eppenbach homogenizing and processing equipment, and a new continuous counter-current chemical processor currently being developed.

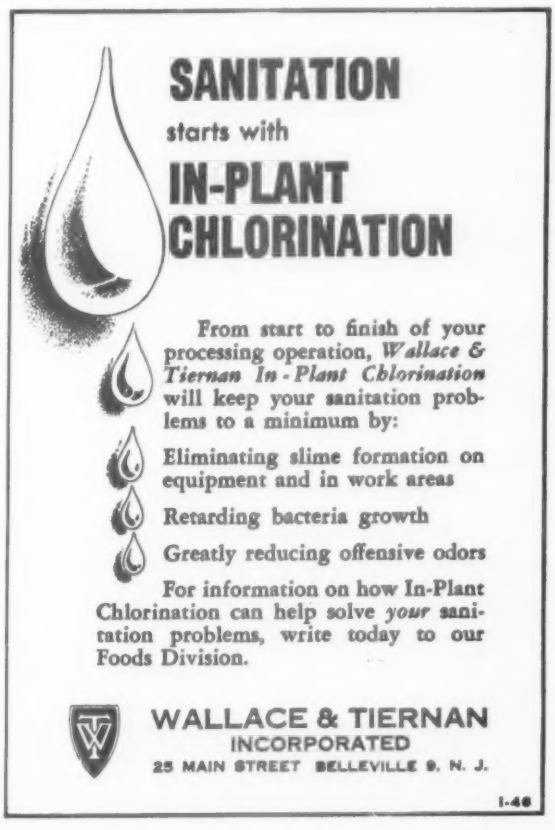
◆ ◆ ◆

Consolidated Foods Corp., Chicago, announces appointments of **H. D. Freeman** as company director of personnel and **Kenneth E. Ketzel** as director of transportation. **Chas W. Lubin,** president of The Kitchens of Sara Lee, recently acquired by Consolidated Foods, has been elected a director of the parent company.

◆ ◆ ◆

Dr. Paul J. Flory, professor of chemistry and acting chairman of the Department of Chemistry, Cornell University, has been chosen to head the investigational activities of Mellon Institute, Pittsburgh, as

(Continued on page 64)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executive director of research. He will join the organization full time in the summer of 1957. Dr. Flory is the holder of 22 patents, and has authored 106 scientific papers and a 670-page book, *Principles of Polymer Chemistry*, published in 1953.

Mellon Institute also announces plans for construction of a million-dollar laboratory, near Pittsburgh, to be completed by late summer of 1957, to house its recently established Department of Radiation Research.

◆ ◆ ◆

Dr. Daniel Swern, research chemist at the USDA's Eastern Utilization Research Branch laboratory at Wyndmoor, Pa., received the John Scott Medal Award from the Philadelphia Board of City Trusts for his inventions of new industrial chemicals from surplus animal fats. The award consists of $1,000 and a copper medal. Dr. Swern's work has resulted in the use of otherwise wasted fats in plastics, paints, wire insulating materials, textile processing, and other industrial products and processes.

RECENTLY ELECTED MEMBERS OF IFT

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Allen Baron
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Brooklyn 29, N. Y.

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Beck Vanilla Prod. Co.
1403-05 State St.
East St. Louis, Ill.

Dr. Ada Marie Campbell
Univ. of California
Dept. of Home Econ.
Los Angeles 24, Calif.

Ing. Fausto Dickinson O.
Reina Xochitl No. 7, Depto. H
Mexico 17, D. F., Mexico

Louis W. Ferrara
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Franklin Park, Ill.

Richard W. Haward
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6050 W. 51st St.
Chicago 38, Ill.

William B. House
Midwest Research Inst.
425 Volker Blvd.
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2207-12th St., N.W.
Winter Haven, Fla.

Donald P. Kosak
61 Walnut St.
Arlington, Mass.

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Edmund J. McLohne
2250 Palmer Ave.
New Rochelle, N. Y.

K. Ray Minert
R. No. 3
Memomonie, Wis.

Prof. Dr. Hermann Mohler
Knorr Nahrmittel AG
Thayngen 7, Switzerland

Sergio B. de la Mora
Laboratorio Quimico De Analisis
Juan de Dios Avias, No. 16
Mexico 8, D.F., Mexico

D. Medina Mora
Productus de Maiz, S. A.
P. O. Box 2936
Mexico, D. F., Mexico

George L. Patrick, Jr.
The Coca Cola Co.
P. O. Box 1734
Atlanta 1, Ga.

Therese M. Pavlik
15 Manchester Pl., Apt. 1-M
Newark 4, N. J.

William D. Paynter
6216 Bridge Road
Madison, Wis.

Margaret M. Roddy
834 Barnett St., N. E.
Atlanta 6, Ga.

Ignacio Rodriguez
Canada 110
Coyoacan, D. F., Mexico

Pedro L. Sanchez-Celis
Anaxagoras 1017 Col. Narvarte
Mexico City 12, D. F., Mexico

Dr. Robert D. Seeley
Anheuser-Busch, Inc.
721 Pestalozzi St.
St. Louis 18, Mo.

David P. Segal
298 Waltham St.
West Newton 65, Mass.

Ramon de la Torre Cortes
Productos de Maiz, S. A.
P. O. Box 2936
Mexico, D. F., Mexico

STUDENTS

Arthur W. Anti
Sigma Phi Epsilon
9 Chestnut St.
Amherst, Mass.

Lois C. Bain
19 Allen St.
Amherst, Mass.

Carcella Barca
70 Fallon Circle
Braintree, Mass.

Paul M. Bennett
418 N. Pleasant St.
Amherst, Mass.

John L. Blaisdell
Univ. of Mass.—Farmhouse
Amherst, Mass.

David A. Fellers
52 Fearing St.
Amherst, Mass.

Haydee Godoy
52 Fearing St.
Amherst, Mass.

Gerald Goldman
TEP House, 418 N. Pleasant St.
Amherst, Mass.

Joe H. Graham
Univ. of Massachusetts
Apt. E-3 Hampshire
Amherst, Mass.

Eugene Kay
TEP House, 418 N. Pleasant St.
Amherst, Mass.

Robert Kepper
54 Washington St.
Milton, Mass.

Athanasios Kiratsous
Univ. of Mass.
Food Tech. Dept.
Amherst, Mass.

David V. Koski
Kappa Sigma, Univ. of Mass.
Amherst, Mass.

N. Irving Lemack
418 N. Pleasant St.
Amherst, Mass.

Joan V. McGrath
Leach Dormitory
Univ. of Mass.
Amherst, Mass.

Murray M. Mitchell
407 E. 8th Street
Davis, Calif.

Sanford S. Rothstein
80-35 Springfield Blvd.
New York, N. Y.

Susan Tagliente
Univ. of Cincinnati
Memorial Dormitory
Cincinnati 21, Ohio

Chee-Teck Tan
Univ. of Mass.
Dept. of Food Tech.
Amherst, Mass.

Paul Touher
Kappa Sigma, Univ. of Mass.
Amherst, Mass.

Charles A. Walsh
117 Greenough Dorm.
Univ. of Mass.
Amherst, Mass.

Leonard A. Yarrows
32 Bliss Street
Florence, Mass.

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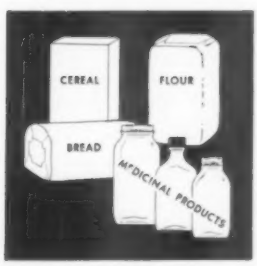

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